POWER PLANT ENGINEERING

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Central Station Load Dispatching

PRINCIPAL FUNCTIONS OF THE SYSTEM OPERATOR, METHODS EMPLOYED TO CARRY LOAD MOST EFFICIENTLY AND PRECAUTIONS ADOPTED TO SAFEGUARD WORKMEN. BY P. B. JUHNKE*

GUARDING THE DISPATCHING of the load from generating station to consumer is the load dispatcher or system operator, as he is variously known in large central station systems in this country.

It is a long and arduous way for the product of the central station to reach its ultimate destination, the customer's premises. This road is divided into a number of well-defined sections, each having different and equally important functions and each being sufficiently different from all others to warrant separate and distinct organizations. To begin with, there is the generating station, the place of production of the raw product and its starting point. A competent executive, called Chief Engineer or Superintendent, here guards over the continuous production of the energy required. His supervision extends also over the efficient operation of the plant, over the personnel of the station and the maintenance of equipment.

Leaving the generating station, our raw product is received by the transmission system, which belongs to the domain of an elaborate organization charged with all construction and maintenance of underground work or of street work, as the case may be. The executive head of this branch or department directs and supervises the installation and maintenance of all cable and overhead line work.

FIG. 3. LOAD DISPATCHER'S DIAGRAM BOARD

Our product, still in the raw state, is conducted by the transmission system into the third stage—the great refinery known as the substation, which, in our larger systems in this country, in point of numbers may vary between 20 and 125. A highly efficient and necessarily complex organization, with superintendent and staff, here

* Chief Load Dispatcher, Commonwealth Edison Co.

carefully insures that the electrical energy is refined to the highest possible degree, and that nothing in its domain interferes with the continuity of the process, which means that the customers receive this refined product—which may be in the form of either direct or alternating current, according to location—in the desired quantity at the proper voltage. This involves supervision over operators and maintenance of apparatus.

Substation organizations, however, are not the last to deal with our product. To reach the customer over feeders, mains and services, the domain of the Underground, Overhead or Street Department, as the case may be, is again entered by the refined product. Even at the ulti-

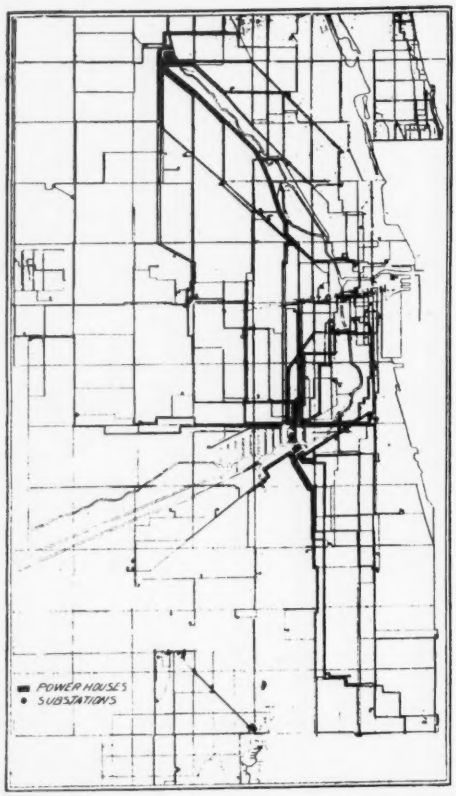


FIG. 1. TRANSMISSION SYSTEM OF LARGE CENTRAL STATION

mate destination, the customer's premises, an extensive organization known as the Meter Department, steps in and forces our product to submit to the metering process.

All these various organizations have well-defined and a multitude of diverse duties to perform, but the supervision of all is limited by the boundaries of their own domain. The intelligent utilization of these various agencies or parts of the system, for the purpose of serving the customer best, is briefly termed "load dispatching."

Relatively early in the history of central station systems the need was felt of a co-ordinating or supervising organization, with power delegated to it by the superior executive of all the aforesaid departments, this organization to be available at all hours to guard the operation of the system as a whole. To the writer's knowledge, the first organization of this kind was established in the Commonwealth Edison Co. in 1904 and the term "load dispatcher" used here for the first time, although functions similar to those of the load dispatcher were exercised of necessity at an earlier date by individuals having primarily other duties.

As we know him today, the load dispatcher, or system operator, is the man who at all times stays in closest touch with the ever-changing operating details in the central station system. Briefly, he has the power and obligation to request, when needed, all the available generating capacity of the system, be it in the form of steam turbines, reciprocating engines or storage batteries. To him alone is delegated the power to order the opening and closing of transmission lines, distributing circuits and feeders. If trouble develops on any of the generating units in one station and relief is necessary from apparatus in other stations, it must be requisitioned by the load dispatcher. If no other idle capacity is available in the form of generating units in other stations or in reserve plants, the battery capacity, if such is available, must be brought into play.

Ordinarily, the load dispatcher can and does rely upon each generating station to be ready to carry load up to the limit of its available capacity, but occasionally an actual shortage occurs in the available generating equipment, due to conditions which cannot always be controlled, such as failure of equipment, a run of low grade coal, failure in condensing water supply due to ice accumulations or unfavorable winds and similar causes. At such times quick action is imperative, even to the extent of temporarily interrupting, through an order, the load that can best be dropped in order to render good service to the bulk of the load. Such load is then picked up as quickly as conditions at the generating station are righted. Such extensive cases of trouble in modern systems are indeed rare. The less frequently they occur, the better and more efficient the work of the load dispatcher.

Where central station systems consist of a number of different generating stations, the operation of the generating system is considerably complicated, especially if, as is almost universally the case, they operate in parallel. Care must be had that each station carries the load it is expected to carry, that the output of each is as intended, bearing in mind the relative efficiency of apparatus in each station. If new apparatus is added, marked progress is discernible, the new units showing distinct improvement in efficiency. To obtain maximum efficiency requires that the load be carried on the most efficient units for the longest time possible, and that the older machines carry only the surplus of the load over the capacity of the most efficient units. This is possible to a certain degree by loading up the tie lines between generating stations and by carrying load over them into the stations having the less efficient machines. To accomplish this intelligently and at all times to have each station prepared for what its own load might be, requires constant watching or else a carefully prepared schedule to guide each station. Such a schedule usually provides for the amount of the tie line load which the station with the most modern equipment may feed into the other and older stations during the different hours of the day. It also simplifies the parallel operation of different stations and at the same time does not interfere with the generating executive's plans or individual responsibilities.

Functions of Load Dispatcher

In service at all times, the transmission and distribution system is under the direct control of the load dispatcher. No line, circuit or feeder can be opened by operators without a direct order from him. He is charged with the issuing of orders necessary to prevent overloading of any element, for overloads on cables are extremely dangerous, as they soon cause the cable involved to break down. If lines or circuits open automatically due to any cause, the load dispatcher must see that the load interrupted thereby is switched back to other lines in the shortest possible time, or back on the lines which opened if the cause of the opening is not a breakdown on the lines themselves. When necessary maintenance or construction work on cable in service is to be done, the load dispatcher's permission must be obtained for the work, and the taking out of service of the elements in question must be done under his direction. He specifies the hours when such work may be done, bearing in mind the load to be carried and the remaining cable capacity. This necessitates a great deal of work to be done at night time, when the requirements of the service are a minimum.

When a line breaks down while in service (in which case the line is opened automatically by the protective relays), the load dispatcher turns it over to the Cable, Underground or Street Department, as the case may be, for location of trouble after he has had the necessary tests made to assure himself that the line is in trouble. Replacing all such lines in service after routine or repair work is completed is likewise done under his direction. Occasionally overloads occur on transmission lines, circuits or feeders, which are reported to him by telephone, and his is the task of providing relief.

In connection with the operation of substations, the load dispatcher's duties are comparatively simple. Each substation, as a rule, has sufficient equipment on hand to handle its normal load. Each operator is expected to put in service enough equipment to take care of the load as it comes up. That each substation has available the required line capacity to load up its transforming or converting apparatus is the main concern of the load dispatcher. In substations feeding a d.c. network, the load dispatcher must see that each substation carries such standard voltage as will give it its normal load and that the voltage on each feeder is kept at a certain standard value. This is possible by the operation of several busses with different voltages. The different feeders are then closed to the bus giving each the proper load and proper feeder and pressure, the longest feeders being closed to the highest bus, medium length feeders to the middle bus, and the shortest feeders to the lowest bus. Once made, a satisfactory feeder arrangement will usually last for weeks and months, unless structural changes are made outside or a load shift due to changes in seasons takes place. Various substations take feeder readings periodically on which the size, ampere load and feeder end pressure are recorded for different hours, such as 1:00 a.m., 2:00 p.m., 5:00 p.m. and 8:00 p.m. These readings are scanned by the office for irregularities, and as soon as observed they are corrected at once by whatever orders may be necessary, such as transferring feeders from one bus to another, by change of standard voltage and similar measures. Sometimes loss of equipment in any one station makes necessary complete changes of standards to reduce the load to the sub-station in question to a point within the limits of the remaining equipment. In large networks this is feasible to a surprising degree. As the entire battery capacity is also placed in or near the d.c. substations and as battery discharges for relieving generating stations are frequent, the load dispatcher telephones orders to this effect to the operator of the d.c. substation in, or contiguous to which, the battery in question is located, who then picks up the load on the battery, at the same time dropping the load on his rotaries. In this manner the load dispatcher is in close and relatively frequent contact with all d.c. substations.

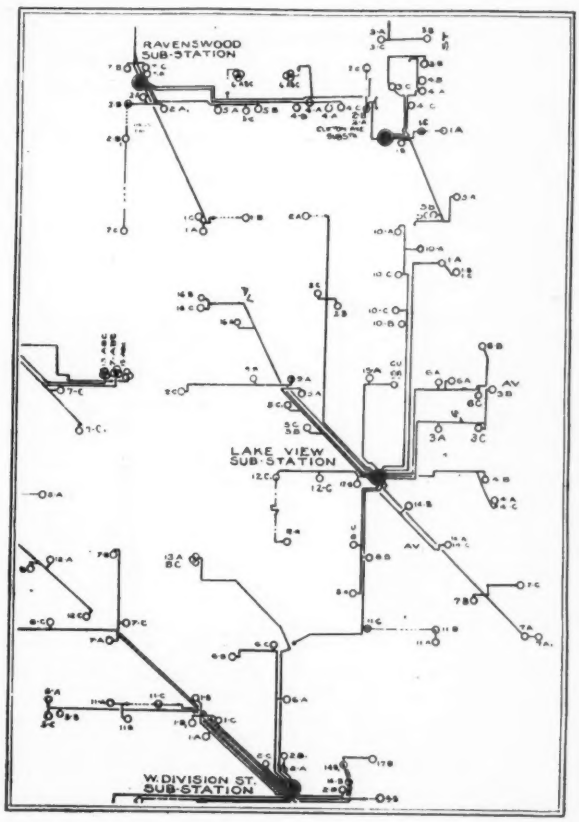


FIG. 2. DISTRIBUTING CIRCUITS FROM 60-CYCLE SUBSTATIONS

Regulation on 4000-v. distributing circuits is looked after by a separate organization, known as Pressure Regulating Division, which determines the circuit compensator settings that will give satisfactory pressure to the customer. There is, however, a great deal of work in progress at all times on the 60-cycle distribution system to engage the load dispatcher's attention. When load is cut over from one circuit to another, both of the circuits in question have to be ordered off the automatic regulators and pressure on both adjusted so that they can be paralleled outside. This, and the taking out of service, as well as the grounding of circuits at the substations for work outside, the replacing in service as well as resuming regulation on such circuits, is all done under the supervision of and on order from the load dispatcher. When

circuits are in trouble due to cable breakdowns or due to wires being down outside, the load dispatcher assigns the clearing of the trouble to the Cable or Overhead Division charged with the repair and maintenance work.

After office hours all complaints of more than a local nature are referred to the load dispatcher, who must assign them to the proper agency to follow up and dispose of them in general, as circumstances warrant. At such times the load dispatcher is the service company's highest available authority to dispose of all matters concerning the company according to the requirements of the moment or along the lines of a well-thought-out routine.

This, in a general way, describes the principal functions of the load dispatcher. An idea of the extent of the different portions of the large central station systems in the country may be obtained from the figures for the system of the Commonwealth Edison Co. In the form of

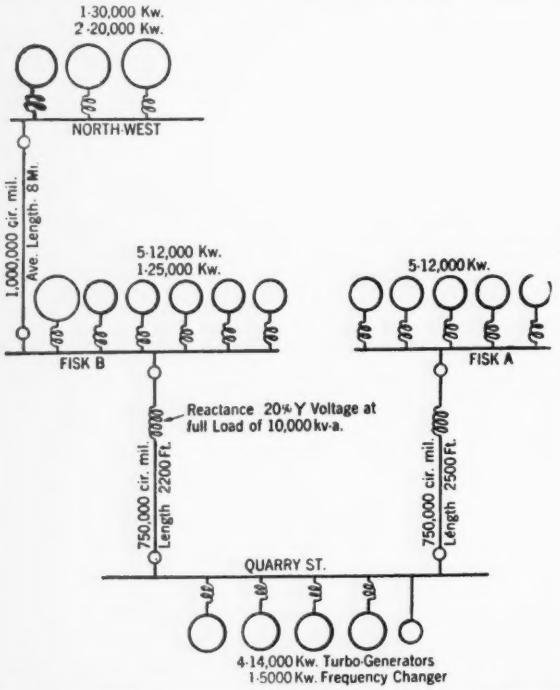


FIG. 4. DIAGRAM SHOWING OPERATION OF 25-CYCLE SYSTEM

turbo-generators, reciprocating engines and storage batteries, the generating capacity comprises in the vicinity of 500,000 kw. The transmission system includes approximately 800 mi. of underground cable, divided into 250 separate and distinct lines; the transforming and converting apparatus approximate 600,000 kw., installed in 121 substations and transformer vaults; the 60-cycle distributing system in the vicinity of 150 circuits, each capable of carrying about 1000 kw. at time of maximum load; and the d.c. feeder system about 500 distinct feeders, each capable of carrying between 250 and 500 kw., depending on size, at time of maximum load. Figure 1 shows the transmission system as it actually exists, and Fig. 2 shows typical 4000-v. distribution circuit arrangements from 60-cycle substations.

Load Dispatcher's Diagram

Intimacy on the part of the load dispatcher with every operating detail of any consequence on the part of the system as a whole necessitates an accurate diagram. Such a diagram may be a straight wall board or it may approach a circular shape, showing in suitable figures the various generating stations and their individual units, the transmission lines, the substations, and the distributing circuits therefrom. Circular rings of an outstanding color and made of gummed paper, about 1 in. in diameter, denote the various generators, paper strips of the same material and ¼ in. wide show the station busses, narrower strips the transmission lines. Oil switches are shown by small circular rings pasted over holes drilled in the board. Plugs are used to indicate when the switch is closed, withdrawal of the plug showing that the switch has been opened. In this manner the entire system can be surveyed at a moment's notice, the board at all times giving an accurate indication.

Substations, with their various transmission lines, transformers and circuits, are shown above the generating stations in much the same manner and are, in the case of the Commonwealth Edison Co.'s board, shown in Fig. 3, arranged in horizontal rows according to the service they render—d.c., a.c., railway and transformer vault service for industrial customers. In systems where the number of stations and lines is relatively large, it is impossible to show the transmission lines in their entirety, as this interferes with the simplicity and clearness. In such cases a panel board, with each substation occupying a separate square, varying between 6 in. and 1 ft. in size, is desirable. Different panels are numbered and the lines feeding the substation are simply indicated by switch connections and numbers. At the generating station, destination of the various lines is indicated by the panel numbers of the substations where they terminate. Figures denoting busses and switches are the same as at the generating station.

On the diagram board in the load dispatcher's office of the Commonwealth Edison Co. are also shown the 4000-v. distributing circuits, but not the d.c. feeders. This was done to comply with the then proposed rules of the Bureau of Standards for the Protection of Workmen, which specified that the load dispatcher must, on his diagram, treat distribution circuits over 2300 v. in much the same fashion as transmission lines.

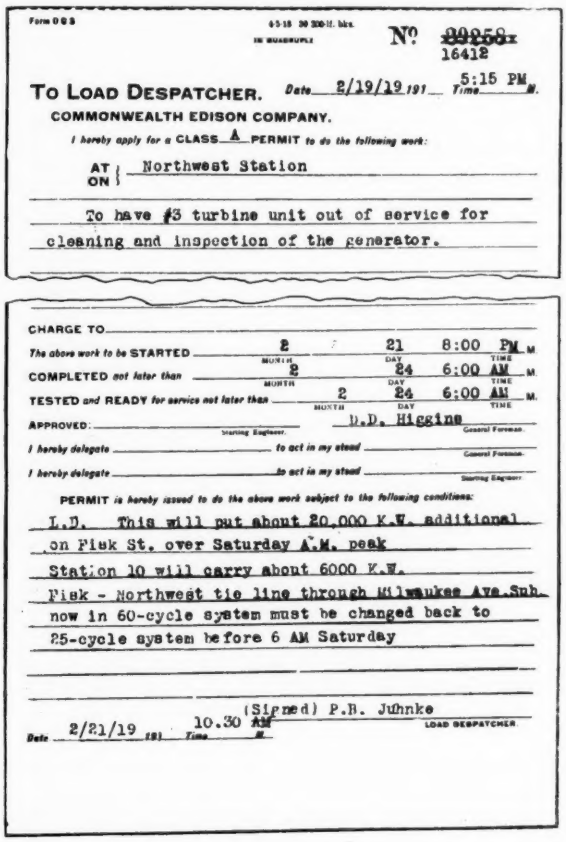
Methods are provided for indicating on this board the various conditions which may obtain on the lines and apparatus. When disconnects are opened on the oil switch of a line, a circular green tag is inserted. When such a line is grounded for any purpose, that fact is indicated by the insertion of a red tag. Relay equipment on transmission lines is indicated as to its type by distinguishing marks or letters.

This indicating board shows distinctly that the entire system consists of a 25- and a 60-cycle portion. A different color scheme is used for each—white gummed paper for the former and orange color for the latter, all on a green background. As the 25-cycle system is further split into three sections, tied through system reactors and operated during the heavy load periods in a manner known as the open ring, it is necessary to indicate the extent of each section. This is accomplished by the use of different colors in the indicating plugs for each section—white, copper and red. Where any two of the three sections may be connected through an oil switch, a large red circular plug is inserted as a danger signal, indicating that this

switch may not be closed, except upon proper load adjustment over the section reactors. Figure 4 shows how the 60-cycle system is operated.

Telephone Board

As the load dispatcher at all times is the man delegated to handle every case of trouble of any magnitude affecting the service, he must have direct communication with all parts of the system in the shortest time possible. For this reason a private telephone board, which can accommodate four men simultaneously, connects the different generating stations and substations over leased direct telephone wires. In case any line or lines become



Form 003 — IN DUPLICATE — No. ~~20958~~ 16412

TO LOAD DESPATCHER. Date 2/19/19 191 Time 5:15 PM M.

COMMONWEALTH EDISON COMPANY.

I hereby apply for a CLASS A PERMIT to do the following work:

AT / ON: Northwest Station

To have #3 turbine unit out of service for cleaning and inspection of the generator.

CHARGE TO

The above work to be STARTED — MONTH 2 — DAY 21 — TIME 8:00 PM M

COMPLETED not later than — MONTH 2 — DAY 24 — TIME 6:00 AM M

TESTED and READY for service not later than — MONTH 2 — DAY 24 — TIME 6:00 AM M

APPROVED: Starting Engineer. D.D. Higgins General Foreman.

I hereby delegate ____ to act in my stead ____ General Foreman.

I hereby delegate ____ to act in my stead ____ Starting Engineer.

PERMIT is hereby issued to do the above work subject to the following conditions:

L.D. This will put about 20,000 K.W. additional on Fisk St. over Saturday A.M. peak

Station 10 will carry about 6000 K.W.

Fisk - Northwest tie line through Milwaukee Ave. Sub. now in 60-cycle system must be changed back to 25-cycle system before 6 AM Saturday

Date 2/21/19 191 Time 10.30 AM (Signed) P.B. Juhnke LOAD DESPATCHER.

FIG. 5. LOAD DISPATCHER'S PERMIT

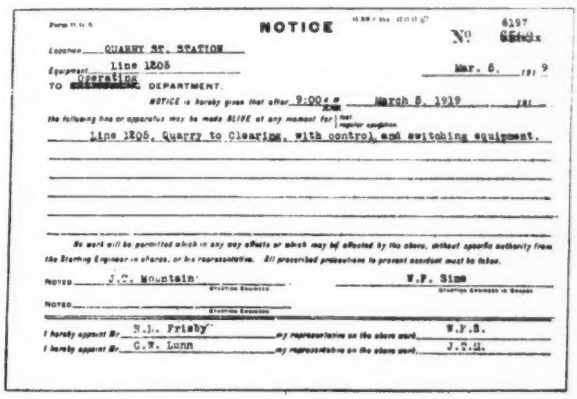
disabled, duplicate lines from the main exchange are available. Thus the load dispatcher is able not only to obtain vital information quickly, but also to give the necessary orders and to receive confirmation of their execution in the most direct manner, thereby restoring conditions to normal in the shortest possible time.

Records

Responsibilities and duties of load dispatchers require that they at all times be thoroughly informed in regard to conditions on any part of the system and to have an intimate detailed knowledge on all parts thereof. For this reason a complete set of maps and records is kept in the office, readily accessible at all times. These records show the routes, lengths and sizes of all transmission lines, feeders, circuits and overhead lines. If, for instance, a manhole explosion should be reported in any part of the city, the load dispatcher would then in a very few minutes have accurate knowledge of every line, circuit, feeder or service main going through that particular manhole, and at once could proceed to kill all or part of them, thereby preventing the trouble from spreading.

Routine for Safeguarding Workmen

Apparatus once put in service is at all times considered in service, under the direct control of the Operating Department, and to take any line or unit of any description out of service requires what is known as a Load Dispatcher's Permit, Fig. 5. An application for such permit is made out by the foreman in charge of the work to be done on a certain part of the system and then forwarded to the Engineer in Charge, who approves it and in turn forwards it to the Load Dispatcher's Office after he appoints a deputy. The load dispatcher then issues the permit to do the work, for such hours as are most suitable, and returns it to the foreman in charge. Before starting the work, the foreman presents his permit to the



NOTICE No. 6197

Location QUARRY ST. STATION

Equipment Line 1205 Mar. 5. 191 9

TO Operating DEPARTMENT.

NOTICE is hereby given that after 9:00 A M March 5. 1919

the following line or apparatus may be made ALIVE at any moment for [ ] operation

Line 1205, Quarry to Clearing, with control and switching equipment.

No work will be permitted which in any way affects or which may be affected by the above, without specific authority from the Starting Engineer in charge, or his representative. All prescribed precautions to prevent accident must be taken.

NOTED J.C. Mountain Station Engineer. W.F. Sims Starting Engineer in Charge.

NOTED ____ Station Engineer.

I hereby appoint Mr. F.L. Frisby my representative on the above work. W.F.S.

I hereby appoint Mr. C.W. Lunn my representative on the above work. J.F.M.

FIG. 6. STARTING ENGINEER'S NOTICE

operator in charge of the apparatus, who, after consulting with the load dispatcher as to taking the apparatus in question out of service, disconnects it in accordance with load dispatcher's orders. Safety devices are then applied, lines are grounded, circuit breakers and oil switches are locked.

After applying proper safety devices for the protection of the men, such as ground connections and locks, the operator attaches "Hold" cards, stating the time they were placed, the reason, name of the load dispatcher who ordered them placed, and name of foreman in charge of the work, whereupon the foreman is permitted to proceed with the work.

After the work is completed the foreman and deputy engineer, the men delegated to make the final check on the apparatus, report to the load dispatcher that the work is completed and that the apparatus is ready for service again. The load dispatcher then orders "Hold" cards removed, which are signed by the deputy engineer and sent to the Load Dispatcher's Office. The apparatus is then put back into regular operation. In the case of transmission lines, the final breakdown and phase tests are made under the direction of the load dispatcher.

Placing new apparatus in service is accomplished through a similar procedure, the basis of which is the

Starting Engineer's Notice, shown in Fig. 6. These are distributed to the various departments through the Load Dispatcher's Office. This form authorizes the load dispatcher to permit new apparatus to be put in service, and thus contributes largely to intelligent supervision and co-operation.

These are some of the most important safeguards which are taken to protect the men engaged in the work, and so far have given perfect satisfaction.

For the purpose of guiding the various departments and individuals therein in their work along safe lines, to have them scrupulously conform to all the measures devised for their protection, and to avoid conflict of authority, the Commonwealth Edison Co. has published a booklet which sets forth in considerable detail exact procedure in all cases, and is called the Book of Rules. This booklet, given to the employes interested, is the always available authority for the load dispatcher and often serves as a reliable guidepost to him in the many unusual situations arising in his daily work.

Personnel

Personnel of the Load Dispatcher's Office is usually recruited from the station and sub-station operating forces of the company, and the men are selected on the strength of their records in such positions. Quick perception, coolness in unusual situations, carefulness and good judgment are the principal requisites. With these qualities a man is equipped to deport himself creditably under the strain of the usual and unusual situations arising in the operation of large systems, to preserve his mental poise in those fortunately exceptional moments of stress when the entire system threatens to go to pieces, and to remain keen and alert when things move as they should.

One-Armed Soldier Becomes Electrical Salesman

SOME men choose their vocations when they are about the age of three years. You've seen a kid, who when he was almost too small to reach the table would try to amputate the cat's leg or perform an appendix operation on sister's doll. All the family would stand around admiring and choose the medical college he was going to attend.

Well, here's one who wasn't much more than snaggle-toothed when he was wiring the house and putting batteries on all the doors. When he had finished the sixth grade (without honor) father said one night that the only thing for Joe to do was to get in an electric shop and earn his own living. There never was a much more perfect moment in that boy's life than when he started down on Monday morning with a tin pail and a pair of overalls.

From 12 to 28 yr. means a passage of time, but Joe was still with the company as a cable splicer. Advancement was there, and he used to look pretty longingly at jobs higher up; but a sixth grade graduation is not much of a foundation for promotion, is it?

That was just before the United States Army packed up and went abroad for a year or so. Joe went with them, and left a star in the company's flag.

One day over there a German machine gun carried away the bottom part of a ledge he was standing on, and with it his right hand and the fingers on his left. Visions of the presidency of the electric company vanished into thin air. Of course the War Risk Insurance Bureau gave him some compensation, but nothing compensates for changing your stand in the world for a seat on the shelf. About that time he got the big news.

The Federal Board of Vocational Education sent one of their men to tell Joe that he wasn't ready to quit and the United States wasn't ready for him to, and offered him a year or so off from work in which he could place a few more stones in that sixth grade foundation. Did he take the opportunity? Well, yes. Just listen to this. Joe entered a technical school and is learning to write a readable hand with that left stump, is taking English, mathematics, accounting and salesmanship, and the reports of him are A 1.

When he gets through he is going to be a salesman in that electric company he grew up with, and is going to make more money than he ever did before, with a good chance of going on up.

Say, wish you could have seen his face when he got that letter from the boss at home telling him his new job was ready when he was! Looked like a tin pan in a New England kitchen.

Hints About Graphite Brushes

CARE should be taken that graphite brushes fit the commutator accurately, otherwise sparking will occur and pit the surface of the brush. The following hints are given by the Joseph Dixon Crucible Co. and should be carefully observed in every case:

When placing new brushes on a machine they should be fitted accurately to the commutator by means of the finest sandpaper. Many new brushes are burned because of improper contact, which causes the whole current to flow through a small area at the heel or toe of the brush.

Sandpaper the contact surfaces and commutator occasionally, as the bearing surfaces of the brushes will take on a high glaze in time and may cause squealing. Let last stroke of sandpaper be in direction of rotation, if machine only turns one way. Use a strip of sandpaper a little wider than brush.

It is absolutely essential that the mica strips be not higher than the copper bars, for graphite brushes are not a grinding brush and will not grind the mica down.

For best results, the spring tension should be low and generally not more than three pounds for any size brush. For low speed machines it may be less.

The commutator must be free from all dirt or oil.

Don't soak graphite brushes in oil or grease.

Sometimes, where neither carbon nor graphite brushes alone give fully satisfactory service, a combination of the two proves advantageous. Put graphite brushes on the negative studs of motors, and on the positive studs of generators.

Brushes must fit their holders snugly or there will be vibration and consequent sparking between brushes and holders. This burns the brush and weakens it mechanically.

Every time you buy a W. S. S. you drive another rivet into your ship of prosperity.

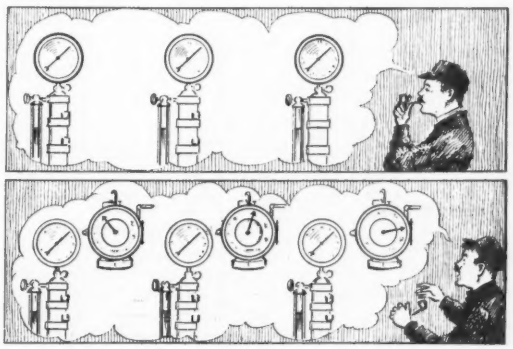
FUEL CONSERVATION LETTERS

By Joseph Harrington, Formerly Administrative Engineer for the State of Illinois

Distribution of Boiler Room Load. Letter No. 14

ONE of the characteristics of the steam boiler is that it has a certain capacity corresponding to its best efficiency. With certain types of firing the capacity-efficiency curve has a very sharp peak, which means that the range of capacity at which the boiler can operate efficiently is very limited. When operating at less or more than this given capacity, efficiency drops off very rapidly. Without question, a flat capacity-efficiency curve is something much to be desired; and the best forms of stokers flatten out this curve very materially as compared with others, and with hand-firing.

There is no use for the loafer, because the boiler in this condition is usually operating at very low efficiency; and by throwing its load on the other units, is overloading them and compelling them to work at low efficiency also. This is one of the most elementary problems in plant operation, and yet it is one that is most often neglected; and without proper instruments, most difficult to detect.



It is a matter which astonishes the fireman when steam flow meters are installed, to see how differently the various units are operating. One boiler will have its flow meter hand clear around on the peg, and the next boiler, without an appreciably different-looking fire, will be loafing along below rating. In an hour or two, this condition may be exactly reversed; and if this condition persists, there is a distinct waste of coal at all times.

It is up to the careful operator, therefore, to take such steps as will assure him that the various boilers in his plant are carrying about the same load, which naturally should be somewhere within range of the most efficient operation. If the plant is large enough to warrant it, one or more boilers should be taken off the line when the load gets down to a point where the average is less than the economical capacity for the unit. Too often do we see every boiler kept in service in little more than banked condition, and operating at 30 or 40 per cent efficiency. It would be far better to run half the number of boilers at twice the rating at an efficiency of 60 or 70 per cent. Standby losses in this case are less than the operating losses.

Now the question instantly arises as to how the operator can tell what load the various units are carrying; and the answer is only by some indicator which shows either the amount of water going into the boiler or the amount of steam coming from it. From my standpoint, either method is satisfactory; but it must be determined for each individual boiler. Only in this way can one tell what is doing. Even the indications of draft are not entirely satisfactory, for the simple reason that a draft reading is an indirect indication. When carefully worked out, with gages to show the loss through the fire and through the boiler, and checked against coal and water rates, the draft indications will show very closely the condition of the fire and the rate of steaming; but there is certainly an advantage in an absolutely direct indication.

In the boiler room we have a national habit of lighting a fire under a boiler and then simply giving it as much coal and water as we can without any regard to its capacity from either the standpoint of efficiency or safety. This is fundamentally wrong, and it can be safely assumed as an axiom that: First, you cannot tell the capacity of a boiler by looking in the furnace; second, you cannot secure maximum plant efficiency unless the unit efficiency is good; and third, you cannot secure unit efficiency unless the load is so distributed that the units can operate at their best efficiency. I have found that while boiler room operatives sometimes tired of looking at instruments, the steam or water flow meter was a constant source of interest.

When a boiler is persistently slow at steaming, the meter will point accusingly at it and call for an investigation. Many a case of dirty tubes, bad baffles, etc., has been discovered in this way. The influence on boiler output of correct feed water regulation, draft changes, and fuel bed thickness, is interesting indeed; and it is a dull fireman who does not readily take to the flow meter and observe its indications.

The Why and How of Ball and Roller Bearing Lubrication

MECHANICAL CONDITIONS INVOLVED WITH ROLLING CONTACT. VIRTUES AND LIMITATIONS OF GREASE. BY REGINALD TRAUTSCHOLD*

MOST certainly, a ball or roller bearing has to be supplied with a suitable lubricant; that is, if the possible mechanical efficiencies of the mechanisms are to be realized. Such a bald statement should be quite unnecessary, but, on the contrary, is much in order, if the shameful abuse to which many such bearings are daily subjected is any criterion. Not only do those who, from lack of mechanical knowledge might be excused in some measure for their actions, display a shocking disregard of the service which can be rendered by the bearings, but even the manufacturers of such mechanisms appear to lack an adequate appreciation of the value of suitable and proper lubricants for their product. The ignorant laborer is under two misapprehensions—that no lubricant is necessary or that any lubricant can be employed, at long and usually irregular intervals. The

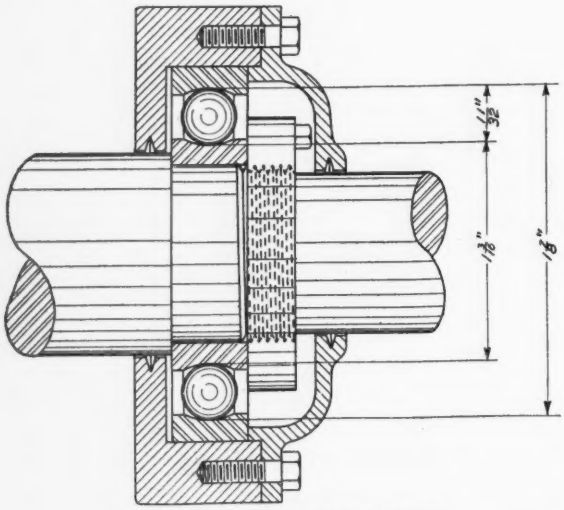


FIG. 1. STANDARD BALL BEARING

manufacturers err quite as much, even though they may specify that lubrication is necessary, in not specifying the grade of lubricant that should be used or in recommending a lubricant that is not well suited to the exacting service of properly lubricating ball or roller bearings.

Lubrication of ball and roller bearings is necessary for the simple reason that the circumferences of the inner and outer bearing races are unequal. The inevitable result is that there must be a certain amount of sliding between the balls or rollers and the races. Theoretically, the rolling members might roll on one of the races, or partly on one race and partly on the other; but there would have to be a certain amount of sliding between the rolling members and those sections of the two races where true rolling contact did not occur. Actually, the total distance on both races over which sliding of rolling members takes place is measured by the difference in circumference of the respective races, that is, provided there is no slippage between the bearing housing and the outer race. Should such latter shippage occur as well, the frictional load of the bearing proper would be aggravated by a resistance similar to that developed in a plain bearing and considerably more pronounced than the unavoidable frictional resistance to the sliding of the rolling members on the races. The assumption may be made, then, that in the case of a properly adjusted ball or roller bearing the sliding action is virtually confined to that taking place between the rolling members and the races. Even this can be quite appreciable.

Take for illustration, a ball bearing of the dimensions shown in Fig. 1, running at 2500 r.p.m. At such speed, the lineal sliding per minute, measured on the ball races, would occur over the quite surprising distance of very nearly 450 ft. The distance through which the rolls would roll in the same time would be considerably greater, it is true, but to force even a highly polished ball of 11/32 in. diameter to slide over 450 ft. of smooth ball race in one minute can, quite evidently, not be accomplished without overcoming considerable frictional resistance.

In the case of a roller bearing of the same diameter and rollers 11/32 in. in diameter and 2½ in. long, the area over which sliding would occur would measure close to 94 sq. ft. each minute, the shaft making 2500 r.p.m. This 94 sq. ft. would not be subjected to any such scouring action as when plain surfaces are rubbed together, but to a scraping action of a series of parallel contacts, as diagrammatically illustrated in Fig. 2.

Roller bearings without lubricant present only line contact between the rollers and the races, just as the actual contact between the balls and races in a ball bearing is concentrated at a point, but when a supply of lubricant is present, even though the lubricant is virtually incompressible, the load is distributed over a material area. The lubricant piles up between successive rollers and the load is transmitted between rollers and races, through the lubricant, as graphically indicated by the darkened areas under the various rollers in Fig. 3.

As for the lubricant, it is quite generally conceded that the practical lubricating medium, considered from the point of view of cost as well as of effectiveness, is of a mineral oil base, a product of crude petroleum. All petroleum products possess the quite necessary properties of low coefficient of friction and high lubricating capacity. The choice of suitable lubricant then resolves itself into a question of selecting the proper petroleum product for the service demanded. The customary failure to make a suitable selection is traceable, ninety-nine times out of a hundred, to ignorance or lack of appreciation of the service demanded.

Lubrication demands for a ball or roller bearing are governed by the rolling action of the balls or rollers to a far greater extent than by any sliding of the rolling element on the races, though, as will be explained, the latter action aggravates the demands upon the lubricant.

SHOULD HAVE SUFFICIENT BODY

WHAT occurs within a ball or roller bearing when in service is most readily explained by means of a homely comparison. The lubricant may be likened to pie-crust

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dough, the balls or rollers to the familiar rolling pin and the act of rolling out the dough to the action on the functioning lubricant. If too great a downward pressure is exerted on the rolling pin when rolling the dough, or the dough is too soft, the rolling pin comes in contact with the surface of the rolling board. Such contact occurs much more readily when manipulating the rolling pin than if a flat board were used instead to flatten out the dough. If a flat board were used, considerable pressure would have to be exerted before it came in contact with the board supporting the dough. Similar conditions occur in ball or roller bearings and plain bearings, thus explaining why a lubricant of considerably more body is required for ball and roller bearings than for a plain bearing of similar diameter under the same load, just as a stiffer dough is necessary to withstand the squeegee action of the rolling pin than is required to resist a normal pressure of the same intensity.

Carrying the comparative illustration a little further, imagine the rolling board replaced by a cylinder surrounded by a continuous layer of dough and a succession of rolling pins all manipulated at the same time. The dough between the various rolling pins would tend to pile up as the thickness of the layer or dough under the various rolling pins was reduced by the normal pressure exerted, much as the lubricant is pictured as doing in Figs. 2 and 3. The lubricant in a ball or roller bearing is acted upon in a similar manner, for to prevent the bearing from running dry in spots, there must always be present more lubricant than actually required to coat evenly the bearing surfaces of the races.

In ball and roller bearings the tendency to pile up lubricant between successive rolling members is more pronounced than would be the piling up of dough between successive rolling pins, for the reason that the lubricant has a greater affinity for the metal balls or rollers than the dough, properly seasoned, has for the rolling pins. The tendency of the lubricant to cling to the rolling members, due to its adhesive property, results in its being dragged over the contact areas, from one reservoir between successive rolling members to the next, just as long as actual contact of bearing surfaces does not occur.

Rotation of the balls and rollers, which must take place in order that the bearings function properly, is productive, however, of two distinct processes. As the rolling members advance along a concentric path paralleling that of the surface of the revolving shaft, the lubricant ahead of each rolling member is pushed and swept toward the roller or ball in advance and the lubricant pushed forward by the following roller or ball is swept between the roller and the race. This action, not unlike that of a rotary sweeper, produces a flow of lubricant between the bearing surfaces of the rolling members and the races just so long as the viscosity of the lubricant is sufficient to prevent contact of bearing surfaces. If the lubricant is not of sufficient body, or it becomes unduly fluid, metal contact will occur, for the adhesive tension of the lubricant to the metal surfaces of the rolling members is overbalanced by the transmitted load. The body of the lubricant and its adhesive capacity must be such as to resist successfully the bearing load.

Its property of adhesion, the tenacity with which it clings to the bearing surfaces, is highly important, even more so than its cohesive properties, though the latter do control the surface tension of the lubricant—a highly important consideration—for the revolving balls or rollers will carry the lubricant through the contact areas so long as the lubricant adheres with sufficient tenacity. Of course, the lubricant must be durable and possess good wearing qualities and have high heat resisting capacity, the generation of heat being inherent to the combat of friction.

Knowing the mechanics of ball and roller bearing operation and the essential properties for a suitable lubricant, the selection of the right lubricant presents a comparatively simple problem. A problem which can be approached with some degree of confidence with the facts known, instead of the too frequent empirical method based largely upon guess work and more or less unreliable past experience.

Advantages and Disadvantages of Grease

Of mineral oil base the lubricant should be of suitable viscosity and not readily affected by variations in temperature. Mineral oil products, disregarding the more recent scientifically compounded products, may be classified as oils and greases. Oils to possess the requisite heat resisting capacity for ball and roller bearing service lack the necessary viscosity, or body, to withstand the

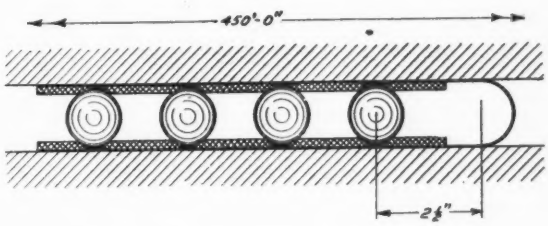


FIG. 2. SCRAPING ACTION OF ROLLER BEARING

severe squeegee action of the rolling members. This is generally conceded and the lighter greases are customarily recommended for the lubrication of such bearings. As ball and roller bearings are mechanisms of precision, the greases usually employed are of the petroleum jelly class, "vasolene," very frequently, being the lubricant recommended.

Petroleum jellies are, under certain conditions, effective lubricants; but they are greases and possess the drawback common to all greases, from a lubrication standpoint. They have to be reduced to lubricating consistency before they can commence to function. In other words, a certain frictional load has to be developed before the grease can be instrumental in combating friction, for heat is necessary to reduce the consistency of the grease and the only available source of heat is that of friction. The petroleum jellies commonly employed for ball and roller bearing lubrication are readily affected by heat, and are of quite low heat resisting capacity; otherwise they would not function in such a bearing. Even under adverse conditions, the generation of frictional heat in such mechanisms is slow and quite gradual, so any melting of the lubricant must occur rapidly with very little application of heat. Combating an ill by a mild attack of the same ill may prove efficacious in medical practice, but it should not be countenanced in lubricating practice; the cure may prove more serious than the original ailment it was in-

tended to benefit. A grease with such poor heat resisting capacity as readily to become of suitable consistency in a ball or roller bearing will as readily become over fluid, if subjected to only a slightly higher temperature. It is true that the temperature rise in a ball or roller bearing is extremely gradual, still a rise will surely occur, for a certain amount of frictional resistance cannot be avoided.

Not only is a grease an unsatisfactory lubricant for ball and roller bearings on account of having to depend upon the generation of a certain amount of frictional heat, no matter how slight, in order to render any effective service, but there is always present a grave danger that the warming up of the bearing may be carried too far and the lubricant become so fluid as not to present the necessary body for preventing contact of bearing surfaces. Once metal contact occurs, the generation of frictional heat becomes very much more rapid and the mechanical efficiency of the bearing materially lessened. The danger of a "hot box" is remote, it is true, which is both a fortunate and an unfortunate condition: Fortunate, in that the destruction of the sensitive bearing is rather

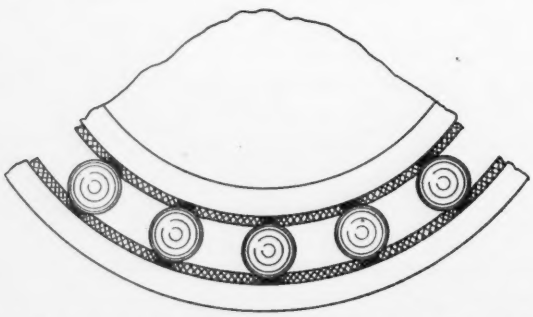


FIG. 3. LUBRICANT TRANSMITTING LOAD BETWEEN ROLLERS AND RACES

well guarded against, in spite of shameful abuse; and an unfortunate condition, in that the inefficiencies due to inadequate lubrication are not more apparent to the average user of such mechanisms. In fact, the very efficiency of the bearing construction would appear to invite the neglect.

An oil of body suitable for ball and roller bearing lubrication is too fluid and lacks the requisite viscosity to withstand the steam roller type of pressure transmitted by the rolling members. In the case of ball bearings the tendency to squeeze the lubricant from the races is even more pronounced than in the case of roller bearings. In the latter construction, the effect of the rolling action is principally to push the lubricant forward, much as in a rolling mill the rollers cause the metal ingot to lengthen to a much more marked extent, while being reduced in thickness, than to widen. In the ball bearing, the action is somewhat different—more like that of pressing one's finger down on a globule of oil—the effect being that the oil spreads out in all directions, radiating from the center of pressure. This peculiarity of ball bearing construction is the fundamental cause of the difficulty in keeping such a bearing oil tight, and explains the unusual precautions quite customarily taken to prevent the escape of lubricant and the entrance of foreign material. To keep gritty materials from entering the bearings is generally advanced as the reason for the need of the so-called "dirt excluding features." In reality, such protections serve quite as important a function, possibly greater, as oil-retaining features.

Greases and oils both possessing marked failings as lubricants for ball and roller bearings, dependence must be placed on the special lubricant products of scientific development for the proper lubricant for such bearings. The correct lubricant should possess the tenacious clinging capacity of a high grade grease, with unusual wearing qualities, and at the same time a degree of fluidity sufficient to allow it to be fed from an ordinary oil can, a fluidity not unlike that of a high grade machine oil of considerable body but free flowing.

Such a class of lubricants is quite evidently to be found only among the individual specialties of leading lubricant producers. These products are compounded on high grade mineral oil base and in some instances by a special process that assures their permanent combination without subjecting the ingredients to the temperature strains that are apt to reduce the heat resisting capacity of the product, yet insures against the presence of any intrained water. They are chemically neutral, a highly valuable property in a lubricant to be used in bearings of precision and high finish, have the required grease-like tenacity of adhesion and yet are quite free-flowing. In addition and of particular importance, they do not have to be heated and reduced in consistency to function, but lubricate at once.

Gun Powder Saves Mechanics' Time

A SOMEWHAT NOVEL idea is in successful operation in the machine shops of the D. & H. R. R. Co. at Watervliet, N. Y. They are using ordinary black sporting powder to save the time of mechanics as described below:

Used for: Blowing nuts and bolts (sweated on) of which there are many in the construction of locomotives and other railroad equipment; breaking up iron and steel to be scrapped; forcing a piston (locomotive) when rust or corrosion binds it; breaking metal that has become cold in a furnace (this has been done at this plant without breaking a fire brick).

Methods of Use: The charge of powder in all cases is loaded in steel guns of various sizes and held by a steel plunger, which is forced out when the charge is set off. No wad is used. The plunger is milled to a size to fit easily the bore of the gun.

They have these guns in sizes from end to end of 5 to 12 in. Some of the gun-barrels are milled in the shape of an octagonal prism, instead of being cylindrical, the bore, of course, in all cases being round.

The gun, after having been loaded, is jacked up with the mouth within about 1 in. of the object to be struck by the plunger and fired. They use approximately 1 oz. powder per nut or bolt (sizes in common use on locomotive construction) that is to be broken off or loosened. The load, of course, is varied with the work to be done.

By the use of these guns, they claim much time and labor has been saved; also a sharp, quick blow can be directed at an object that is barely reachable otherwise.

THERE ARE two kinds of dollars—one that is never worth more than a hundred cents, and one that grows in value. When you put your money in War Savings Stamps you change your hundred-cent dollars into the kind that grow.

U. S. Nitrate Plant No. 2---II

SECOND ARTICLE IN THE SERIES DESCRIBING THE TURBINES AND CONDENSING EQUIPMENT. BY EDWARD R. WELLES AND W. A. SHOUDY*

AT THE time of the entrance of this country into the World War, the Duquesne Light Co., of Pittsburgh, had on order a 60,000-kw. turbo-generator. The changed conditions resulting from our entrance into the war made it advisable to postpone shipment of this unit, hence it was available for Nitrate Plant No. 2. All work had been stopped on this unit, but it was immediately replaced on the schedule and the first element shipped in September and the entire unit including condenser and auxiliaries shipped within a year,—a remarkable manufacturing record.

The turbine is a triple element cross compound, consisting of one high-pressure, single-flow turbine running at 1800 r.p.m., which exhausts into two low-pressure, double-flow turbines, each of the three being equipped with a 20,000-kw. generator. The unit has a continuous rating of 60,000 kw. at 85 per cent power factor, 60-cycle, 3-phase, 12,200-v. and has a peak load capacity of 70,000 kw. The large size makes possible higher operating economy, as the guarantees given below will indicate. It will be noted that these guarantees are undoubtedly conservative since the lowest steam rate is less than 75 per cent of the Rankine efficiency.

The division of the unit into three elements makes it possible to operate any combination of one, two or three elements, thereby avoiding the loss of the entire unit in case of a minor accident to one of the elements. It also permitted the erection and operation of one element before the completion of the others.

FIG. 11. INTAKE CANAL AND COVERED DISCHARGE TUNNEL DURING CONSTRUCTION

CONTROLLING DEVICE

THE HIGH-PRESSURE element is furnished with the usual governor for close regulation. Each low-pressure element is provided with an additional governor for wide regulation, about 12 per cent. The extremes of movement of this governor at one end close a butterfly valve in the low-pressure turbine inlet; at the other end it will begin to admit high-pressure steam to the low-pressure element. The usual stop governor on the high-pressure element will close the main automatic throttle only and those on the low-pressure element will shut the butterfly valve in the low-pressure inlet and the live steam inlet to this element.

* Mechanical Division, J. G. White Engineering Corp.

When any of these automatic throttles operate it will open a switch which will in turn open the main circuit breaker of the particular element involved. Electrical contacts on each low-pressure governor will indicate to the switchboard operator the respective positions of these governors. A remote control of this governor will permit its operation from the main switchboard.

The high-pressure turbine is provided with a bottom exhaust opening to which is attached a special back-pressure valve. This valve must be tight against both pressure and vacuum and open at any predetermined pressure. In the event of one low-pressure turbine not operating, this valve will exhaust to the atmosphere such steam as cannot be accommodated by the other low-pressure element. The operation of this apparatus is about as follows:

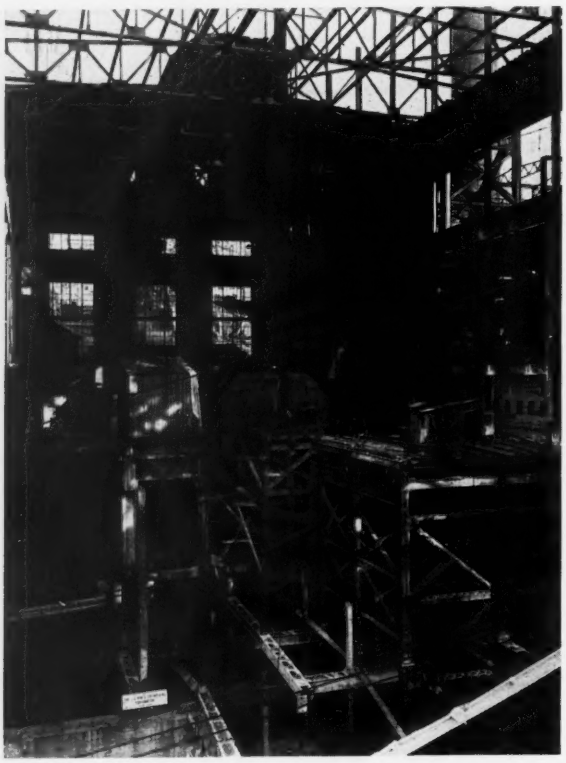


FIG. 8. LEFT HALF LOW-PRESSURE ELEMENT OF TURBINE DURING ERECTION SHOWING HEIGHT OF FOUNDATION

In the event of one low-pressure circuit breaker opening, the element will tend to increase in speed. The low-pressure governor will, therefore, close the butterfly valve between the high-pressure and low-pressure element and the load will be adjusted between the two remaining elements.

In the event of one low-pressure turbine safety stop being knocked out, this will close the automatic live steam throttle to the low-pressure turbine and the low-pressure steam butterfly valve.

In the event of the high-pressure circuit breaker opening, the element will speed up and its governor shut off steam from the whole system. The low-pressure elements will then slow down and their governors will open to admit live steam direct to the turbines and the frequency of the low-pressure units will be brought to normal by remote control.

In the event of the high-pressure turbine safety stop being knocked out the governor will close the main automatic throttle, shutting off steam to the whole system. This action will in turn open the high-pressure main circuit breaker and the load will distribute to the low-pressure units. This will reduce the speed of these elements and the governor will operate the high-pressure valve to admit high-pressure steam directly to the low-pressure element.

Economy

THE BUILDERS' guarantees for the turbine when operating at 275 lb. gage pressure per sq. in. and 175 deg. F. superheat are as follows:

When operating as a complete unit

	——Lb. steam per kw.-hr.——	
Load	29 in. vacuum	28.5 in. vacuum
30,000 kw.	11.05	11.55
40,000 kw.	10.75	11.15
50,000 kw.	10.75	10.90
60,000 kw.	10.75	11.10

When operating one high and one low-pressure element

30,000 kw.	12.1	12.45

When operating one low-pressure element on high-pressure steam

20,000 kw.	14.0	14.45

30,000-kw. Unit

ALTHOUGH the second generating unit had not been definitely selected in all probability it would have been a tandem compound having a continuous capacity of 27,500 kw. at 85 per cent power factor 30,000 kw. maximum. The following guarantees are interesting when compared with the larger unit.

Load	29 in. vacuum	28.5 in. vacuum
27,000 kw.	11.18	11.67
25,000 kw.	10.85	11.33
20,000 kw.	10.70	11.16
15,000 kw.	11.18	11.67

Condensing Equipment

SINCE EACH of the low-pressure elements is provided with two exhaust nozzles, four condensers are installed each with 25,000 sq. ft. of tube surface. The normal supply of circulating water will be furnished by three 44,000-g.p.m. motor-driven centrifugal pumps giving a total of 132,000 g.p.m. or a ratio of circulating water to steam of slightly under 100 to one. This high ratio was selected because of the comparative temperatures of circulating water. The guarantees given below show that even with 80 deg. water the turbine will operate with at least 28 in. vacuum. A fourth circulating pump is installed both as a spare and also because by the occasional operation of four pumps the excessive velocity through the tubes will tend to clean them by scouring. When but two pumps are operating, the reduced friction head through the condenser increases the capacity of the pumps, hence about 53,000 g.p.m. is discharged by each pump, or a reduction of only 20 per cent on the total circulating water. The effect on the vacuum with 60 deg. water is hence very slight, 0.2 in. at 50,000 kw.

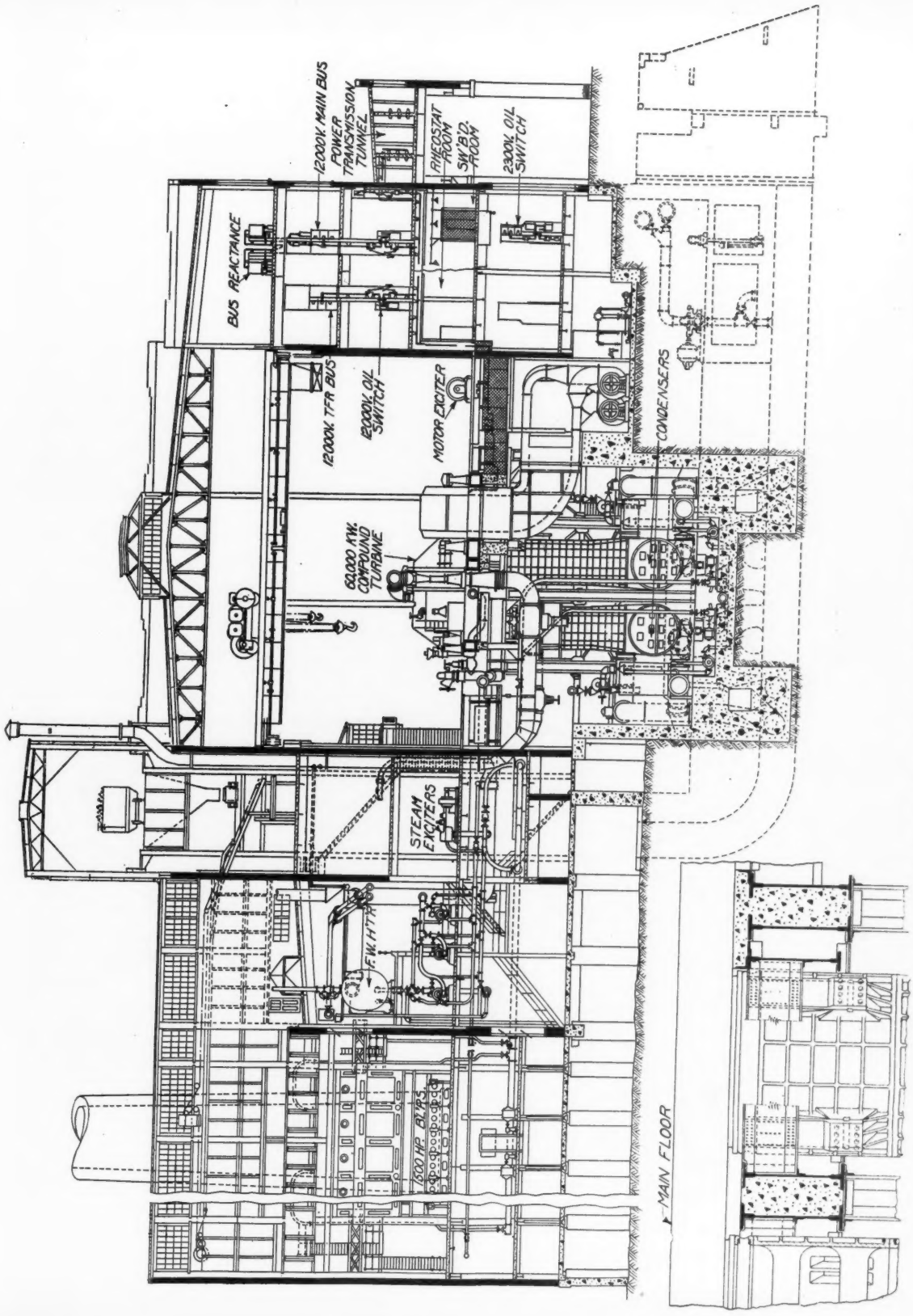


FIG. 9. CROSS SECTION OF POWER HOUSE AND DETAIL OF METHOD OF HANGING CONDENSERS

COMBINED TURBINE AND CONDENSER GUARANTEES

Turbine Load	Lb. Steam per hour through turbine	Vacuum In. M.
		3 Circulating Pumps 132,000 g.p.m. 80 deg. Circulating water
30,000	345,000	28.55
40,000	450,000	28.40
50,000	550,000	28.20
60,000	685,000	27.95
		70 deg. Circulating water
30,000	335,000	28.90
40,000	436,000	28.80
50,000	540,000	28.65
60,000	670,000	28.45
		60 deg. Circulating water
30,000	328,000	29.20
40,000	427,000	29.10
50,000	528,000	29.00
60,000	653,000	28.90
		2 Circulating Pumps, 106,000 g.p.m. 60 deg. Circulating water
30,000	332,000	29.00
40,000	433,000	28.95
50,000	534,000	28.80
60,000	659,000	28.65

consideration, however, was in general similar to that of the larger unit but of proportionately smaller size.

METHOD OF INSTALLING CONDENSER

THE NECESSITY for providing for protection against flood conditions of approximately 35 ft. above low water

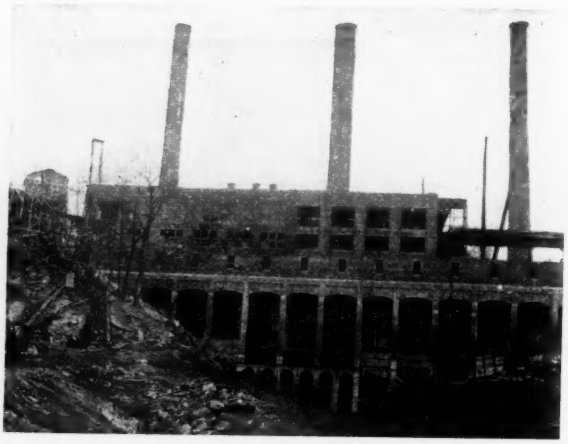


FIG. 12. VIEW OF PLANT FROM RIVER DURING CONSTRUCTION

made it necessary to place the ventilating duct for turbine ventilation not less than 37 ft. above low water. To accommodate these large air ducts it was necessary to place the turbine 25 ft. higher. Since this flood condition would occur for comparatively short periods, it was necessary to install circulating pumps and condensers as close as possible to low water. A very careful in-

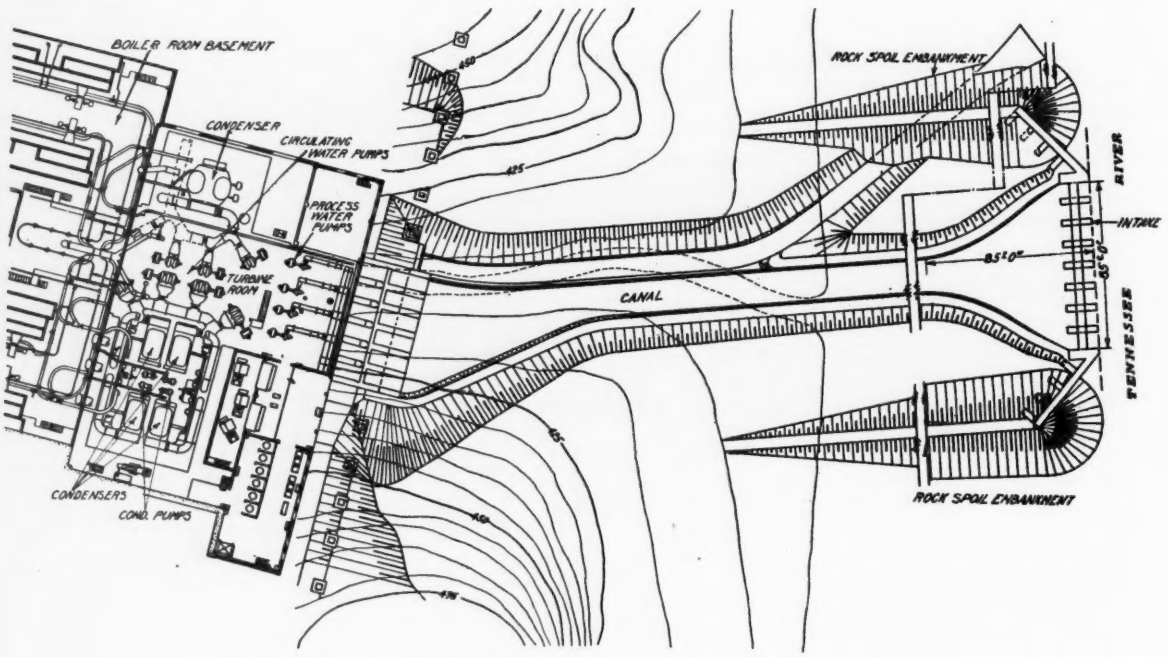


FIG. 10. PLAN OF CONDENSER PIT AND CONDENSING WATER INTAKE CANAL

The condensing equipment for the second generating unit had not been definitely decided upon at the time of the signing of the armistice. The equipment under

vestigation of other installations indicated that the highest point of the circulating system should not be greater than 25 ft. below the discharge water level if full advantage was to be obtained from a closed circulating system. These conditions necessitated placing condensers in a pit 50½ in. below the turbine floor, the condensate pumps being installed in a smaller pit approximately 7 ft. deep.

The casting connecting the turbine exhaust with the condensers is approximately 30½ ft. long. There are four of these of four sections each, oval in cross-section, approximately 15 by 9 ft. inside dimension. This oval section made it impractical to use the mercury type expansion joint, and in addition this type of joint would have seriously delayed the construction program. The use of another type of joint did not seem advisable, hence it was decided to hang both the condenser and the exhaust casting from the turbine foundation, thus eliminating large expansion joints and to a large extent also eliminating vacuum strains on the turbine foundation. The weight of each of the four exhaust connecting pieces assembled is approximately 200,000 lb., the weight of each condenser filled with water approximately 400,000 lb., making a total weight of 600,000 lb. supported in this manner.

The method of hanging the condenser is shown in Fig. 9.

Rubber expansion joints are used between the condenser shell and all condenser piping.

Intake Canal and Discharge Tunnel

The intake at the end of the ravine at the river edge is provided with a series of floating dams which tend to keep surface refuse from entering the intake canal. The ravine was excavated near the river edge to provide for the intake canal and the screen chamber was made a part of the front wall of the power station. There are installed in this screen chamber six vertical traveling screens, each being made up of continuous screen trays 78 in. wide by 18 in. pitch. These six screens are driven by a common line shaft, jaw clutches permitting the cutting out of any section.

The discharge conduit is covered to avoid mixing with the intake water during the high-water periods and leads to the river edge in the downstream side of the intake.

Learn to Think

By H. A. Cranford

"You can lead a horse to water,
But you cannot make him drink;
You can stuff a man with knowledge,
But you cannot make him think."

IT'S not how much a man knows that counts, but the use that he makes of his knowledge. One of my old schoolmates was what we termed a drone while he went to school. He never went very far in his studies, yet today he is one of the successful boys of our old class. He APPLIED what little knowledge he gained.

When the average man has the misfortune to become maimed in any way his friends generally gather around him and offer their sympathy, and keep his mind filled with the fact that he has become seriously handicapped, and do all they can to convince him that he hasn't an equal show with his more fortunate fellowman, until, even though unconscious of it, he begins to feel pity for himself. No man could be in worse condition than that.

Somebody has said that "It's brains that count these days." Well, that's so to a certain point. Milton had brains, Longfellow, Emerson, Jack London and lots of them had brains, but big, muscular Jack Dempsey, with a quick brain and muscles of steel, made more in his big fight than most of the brainy ones made in a lifetime.

It takes a well-balanced man to succeed, whether he be whole or maimed, and most of us working people have gone along developing our muscles and neglecting our brains. Then we happen to have an accident that deprives us of part of our muscle. We have to begin everything over, and if we do not get in the habit of pitying ourselves we begin to get down to hard study, and look things square in the face. And this is about the first time that some of us discover that we really have brains. As a result we start the development of our mental organs.

There are just two classes of crippled people, those who are so weak mentally that they drift to self-pity, and those whose mentality is enough to make them fight self-pity. You will find the former class sitting in doorways begging. The other class you will find in office, shop, engine rooms, etc. To the employer I would say that the fact that a cripple is willing to attempt the duties of a position should be reason enough for trying him in the position. For the last number of years I have given preference to cripples. I always explain the nature of the work that I want done, and ask them if they think they can do it. I do not allow myself to form an opinion as to whether they can do the work or not. I have never been disappointed but once. The cripple can figure out how he must do certain things, where you couldn't see for your life how he would go about it, and if you asked him, he couldn't tell you.

It's an uphill fight for the cripple for the reason that an employer will hire a whole man, assume that he is able to do the work, and pay very little attention to him. But when he hires a cripple he will watch him closely because of his doubt in his ability, and little things that would never be noticed in the whole man's work will stand out as if under a magnifying glass. This fact, however, will be of value to the cripple, for it makes him "get on his toes" to make good, while the other fellow has no such incentive, and as it is a law that a man either goes backward or forward, the whole man will drift backward if he doesn't watch out.

The natural brain is gyroscopic in its nature. When the gyroscope is not in motion it can be pushed or turned in any direction. Just so with a dormant brain. But when it is brought up to full speed it will exert every ounce of its power against the point where pressure is applied, and under natural conditions will, to a greater or lesser degree, overcome the pressure that is trying

to force it out of its natural position. Just so with the human brain. When a man becomes physically handicapped, the healthy brain resents the resistance that it offers to the success of the man, and if given a fair chance will resist the handicap and furnish the power to overcome it.

My whole object in writing these articles is to awaken the cripple to his opportunities, and the employer to the fact that he is a big loser when he fails to give the cripple his rightful chance to be self-sustaining and independent. I have always felt that if each one would study the other's interests more there would be fewer problems to be solved.

An amusing incident occurred in our place the other day. A friend who is one-handed was sitting in his office when a fellow with three fingers off one hand and a slight limp came in begging. He was a big, husky fellow. When he approached this friend (my friend, like myself, hasn't much time for beggars, especially one-armed men), told him that he should get out and work, that he did so himself and supported a wife and four children. The beggar replied, "Well, you are not crippled as badly as I am." As quick as a flash my friend jumped up with a hammer in his hand and started after him, saying, "And you are not crippled as badly as you are going to be in a minute." That beggar sure forgot his limp while getting out of there.

Several years ago I was standing on the street in our city, leaning against a telephone pole. My left hand is off and that side was toward the pole. A one-armed beggar approached me from the right side with a change box in his hand with considerable change in it. He asked me to help a cripple. I refused. He started abusing me for not helping the unfortunate, said that I should never turn down a cripple, should give him part of my good fortune in not being crippled. I let him talk a minute or so, then asked him if he practiced what he preached. He replied, with an oath, that he did. I turned around so that he could see that I was crippled. He was very profuse in his apology, said he wouldn't have begged me if he had noticed I was crippled. I insisted that he divide with me, but it didn't work. I saw him several times afterward, but he would always dodge me. If the public would only realize that the average cripple is not deserving of charity we would be better off. Of course there are a few exceptions. But 95 per cent of the crippled beggars are beggars at heart, and would have been some kind of beggar if they had never been crippled.

Mr. Employer, the next time a healthy cripple applies to you for charity, offer him a job. If he is the right sort he will appreciate it, and you will each be the winner. He will make you a good man if given an equal show with his more fortunate brother, and his gratitude to you for a chance will be an incentive for him to work up.

If he refuses the offer of work, then don't help him, for he is not worth it, and the quicker he starves to death the better off society will be, and you will be benefiting society whether he refuses or accepts.

The liberality of the American people fosters the spirit of begging. A man who never was able in his life to average two dollars a day gets a foot or hand chopped off while stealing a ride from the railroad, gets a seat on the pavement on some busy corner and his income soon reaches a figure that is sometimes almost astounding. We preach safety first, and work to lower the chances for accidents; but at the same time the liberality of the people toward beggars makes a certain class dread an accident much less. You may think these statements are rather broad or radical, or whatever you want to call it; but I have studied cripples for nearly 14 yr., in the office, shop, beggars' boarding houses, dope joints, etc., and I have found but three beggars that had lost an arm or limb that were not capable of EARNING a living.

If you had talked to as many professional beggars as I have talked to you would soon be the means of ridding the country of them. Have you noticed that during recent months, when money was plentiful, there were more beggars on the street than ever before?

I intended when I started this article to write more about how the various things in an engine room were accomplished by a one-armed man; but the main thing is to THINK, analyze. We say that a flower is beautiful. Do you ever stop to think why it is beautiful? We hear music that soothes us, but do you ever stop to analyze the many notes and sounds that go to make up the harmonious whole of it? The eternal WHY of all of it?

When the cripple gets down to the WHY of things, the WAY of things will unfold itself to him. To the employer I want to suggest that he ask his employer acquaintances if they have any cripples in their employ, and when he hears of a cripple being in any kind of work, get a line on what he is accomplishing. This way he will be surprised at the success the cripples are making in all walks of life. There was a Carry-On Club formed in this city for the purpose of assisting returned maimed soldiers. The members must be men who were crippled that were making a success.

When the crowd gathered it was a surprise to everyone. There was a big bunch in every walk, trade or profession of life. I tell you that the cripple who learns to think can do anything he tries to do. It will be money in the employer's pocket when he learns that fact. "HE CAN WHO THINKS HE CAN."

THE REPORT of the Sea Service Bureau of the Shipping Board for the month of June, made public recently, shows that during that month 1,518 officers and 10,285 men were given employment in our Merchant Marine. While private agencies charge fees for shipping men, operating owners or captains are under no such expense when obtaining men through the Sea Service Bureau of the Shipping Board.

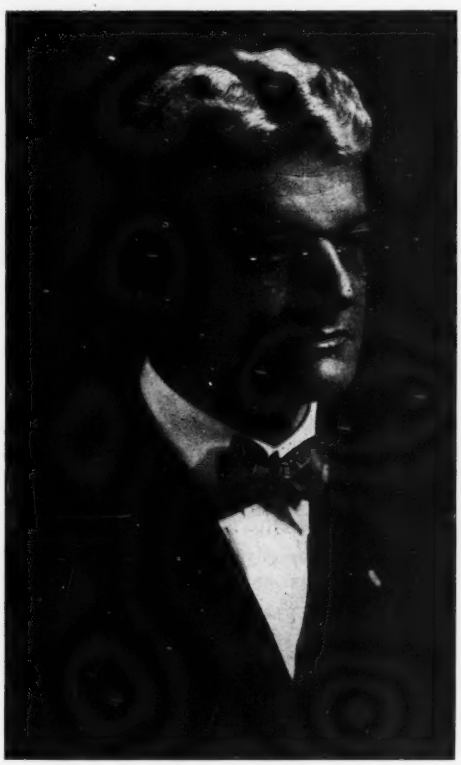
U. S. CIVIL SERVICE COMMISSION announces an examination, Aug. 12, for research operator—metallurgical, for men only. Vacancies under the Ordnance Department of the War Department, for duty at ordnance plants, arsenals, or in Washington, D. C., will be filled from this examination. The register of eligibles will be divided into two grades, as follows: Grade I, $1500 to $2000 a year; Grade II, $2000 to $2500 a year. After 6 mo. satisfactory service in Grade II, appointees will be eligible for promotion to Grade III, in which the salaries range from $2500 to $3000 a year. Apply for Form 1312.

R. SANFORD RILEY

EARLY WORKED HIS WAY AROUND THE WORLD AS MARINE ENGINEER AND GATHERED UNUSUAL EXPERIENCES. THEN WORKED HIS WAY UPWARD TO AN INDUSTRIAL LEADERSHIP. BY WALTER PAINTER

ONE of New England's busiest and biggest citizens is R. Sanford Riley.

Mr. Riley was born in Canada 45 yr. ago, and spent his boyhood days in Winnipeg. Both his father and mother were descendants of old Yorkshire, England, stock, and his great-grandfather served as an officer in the Napoleonic wars. His father is now an eminent Winnipeg banker.



He received the common school education offered at Winnipeg, and at the age of 22 was graduated from Worcester Polytechnic Institute as president of his class. This was the first real indication of his potential executive powers. He assumed a prominent part in all collegiate activities, utilized his brawn as center of the football team and unfolded some early literary talent as editor of the class book.

Soon after leaving school he decided that shipbuilding offered a wide future and accepted a position with the Cramps Shipbuilding Co., as draftsman, receiving $2 a day.

At 24 he started from Cramps shipyard in Philadelphia, and spent the next 5 yr. working his way around the world as a marine engineer and soldier of fortune. His first trip was in the "Admiral Sampson," which he had helped to design. Crossing the Pacific, he worked his passage as ninth assistant engineer on the R.M.S. "Empress of China." In Hong Kong he joined the United States Navy, and went through the Boxer campaign. In maneuvers under General Funston he assisted in the capture of the Filipino insurrectionist, Aguinaldo. Coming home by way of the Indian Ocean and Suez Canal, he served as chief engineer of the "Arethusa," a base ship for torpedo boats.

At the age of 29 Mr. Riley overcame the lure of the sea and entered the employ of the New York Ship Building Co., at Camden, N. J., as assistant to the chief engineer. He followed up trial trips and served as guarantee engineer on a big government dredge during the opening of one of the passes in the delta at the mouth of the Mississippi River.

As a mark of his marine engineering ability, Mr. Riley was awarded the rating of Extra First-Class Engineer by the British Board of Trade, the highest certificate of competency issued by that body. As Chief Engineer for Unlimited Tonnage he holds the highest marine engineer's certificate rendered by the United States.

Mr. Riley grew. He acquired that intelligent grasp on various business phases which has aided so many engineers to achieve success with large projects. His mechanical and executive ability soon received recognition, and at the age of 32 he was made manager of the American Ship Windlass Co. of Providence, R. I. Here he utilized his broad naval engineering experience in the development of designs for windlasses, steering engines and other marine engineering equipment. It was here also that Mr. Riley entered the underfeed stoker business by taking the Taylor stoker, as left by the death of the inventor, and developing it into a successful commercial device.

In 1911 Mr. Riley sold his interests in the American Ship Windlass Co., developed the Riley underfeed stoker and organized the concern bearing his name. He is also president of the Murphy Iron Works of Detroit.

He was one of those big and busy men who contributed valuable aid to the government in solving its engineering war problems. His services were asked by the Emergency Fleet Corporation, under Charles M. Schwab, to organize a Performance Section. Mr. Riley says that this work afforded him some of the most interesting experiences of his career. It involved traveling widely over the country, visiting shipyards and arranging for trial trips, investigating troubles, and advising as to their remedy. Incidentally, the renewal of old acquaintances in the shipbuilding and sea-going fraternity was especially gratifying.

In 1918 Mr. Riley rendered an efficient administra-

tion as president of the Worcester Chamber of Commerce and was re-elected for 1919. He is vice-president of the Worcester Y.M.C.A. and affiliated with numerous local organizations and clubs. He is a member of the A.S.M.E., the American Institute of Naval Architects and Marine Engineers, the Engineers' Club of Boston and the Engineers' Club of New York. Based on his engineering experiences, ashore and afloat, he has contributed numerous papers and discussions, particularly on combustion questions.

Mr. Riley is everlastingly a climber. He has scrambled over the crags of the highest Swiss Alps and the loftiest of the Canadian Rockies, and socializes his mountaineering pleasures as a member of the Appalachian Club and the Alpine Club of America. He is also extremely fond of riding horseback.

In 1904 Mr. Riley married Miss Katharine Higgins of Worcester, Mass. Quite conspicuous in his office is a photograph of his cheerful family, with five children grouped about the fireside of his home.

Possessing a powerful physique—he is well over six feet in height and correspondingly broad—Mr. Riley has a vast store of energy, and he has utilized that force to convert inertia into momentum in his commercial projects just as it wedged open a gap for a gain in his football days. One of his intimate friends said: "Riley holds that happy quality known as the ability to work in the spirit of play." He has a pleasing voice, a happy personality and a wealth of enthusiasm.

Responding to the query as to what requisites he considered of paramount importance to a successful engineering career, he said: "First of all, a love for making things, an ideal of perfection and the industry to achieve that ideal." Mr. Riley believes thoroughly in Thomas A. Edison's description of genius as "2 per cent inspiration and 98 per cent perspiration."

Pulverized Coal

Information Presented at A.S.M.E. Meeting Shows Rapid Advance in Use of this Fuel in Power Plants

CONDITIONS resulting from the participation of the United States in the World War have forced engineers and managers of industries to give more thought and experiment to the use of fuels which will tend to conserve the main body of our fuel supply. Among the fuels which have received an unusual amount of attention is pulverized coal, and as a result of investigations one session of the spring meeting of the A.S.M.E., held in Detroit, June 16 to 19, was given over entirely to the reading of papers upon that subject and discussions which showed conclusively that pulverized coal for boiler furnaces has gone beyond the experimental stage, so far as feasibility is concerned, but like all other fuels, it has a distinct field, when the economy of the problems is concerned, that evidently has not been well defined as yet.

It was the opinion of Frederick A. Scheffler and H. G. Barnhurst, as expressed in their paper, that best present-day practice of firing boilers in power plants of moderate and large capacity has attained the maximum efficiency that might be expected, and that if we are still further to conserve the coal fields of the country and in addition reduce the operating costs in the use of fuel and labor, some other method of firing boilers by coal must be adopted.

The authors then make a comparison of the stoker with pulverized-fuel plants, in which the following statements are made:

"Reliability depends on two items: apparatus for preparing and presenting the fuel for combustion, and continuity of operation of the furnace itself. That the mechanisms for pulverized fuel are reliable is proved by their widespread use for years in the cement industry and more recently in an ever-increasing variety of industries. Proper design of equipment by engineers of standing who are specialists in this line has made negligible the danger of dust explosions.

"The second condition is altogether outside the furnace, hence cleaning and adjustment and the making of the few repairs required need not interrupt the operation of the boiler. In case of sudden necessity the fire may be ignited and quickly brought to full intensity, or it may be extinguished almost instantly. Greater uniformity of flame and temperature is conducive to longer life of the furnace lining in a properly designed furnace, and to the minimum variation in furnace efficiency. Finally, the pulverized-fuel installation relieves the power plant from dependence upon the availability of a certain grade of coal."

In considering the cost of preparing the fuel it was stated that, "When central pulverizing plants are built, they will relieve small power plants of the necessity for maintaining pulverizing equipment and make pulverized fuel considerably cheaper, regardless of the size of installation. This feature is already being carried out successfully.

"In adaptability pulverized fuel is pre-eminent. The primary feature is the possibility of burning all grades of fuel without affecting the efficiency of the furnace. To burn anthracite and very low grades of fuel requires a furnace allowing a return flow of the flame past the incoming flame, to heat up the incoming fuel, and in a furnace of this type fuel containing over 50 per cent ash has been burned with high efficiency.

"The flexibility in the use of pulverized fuel is perfect, and the fire may be instantly adjusted to suit any condition of overload or lower load, including the cutting in and out of the boilers.

"The primary requisite for good results is to maintain low velocities in the furnace. The combustion is no less perfect with high velocities, but this will result in damage to the linings and in their erosion. A furnace cubical in shape usually gives the most satisfactory results.

"The burners should inject the coal under low pressure and should permit of varying the density of the mixture in the burner itself. Their location and number will depend upon the size of the boiler and rating

required, and also may be varied to suit the grade of fuel. High boiler ratings such as are used in modern boiler practice can be obtained when desired, and such overratings should be predetermined and the furnace volume designed accordingly."

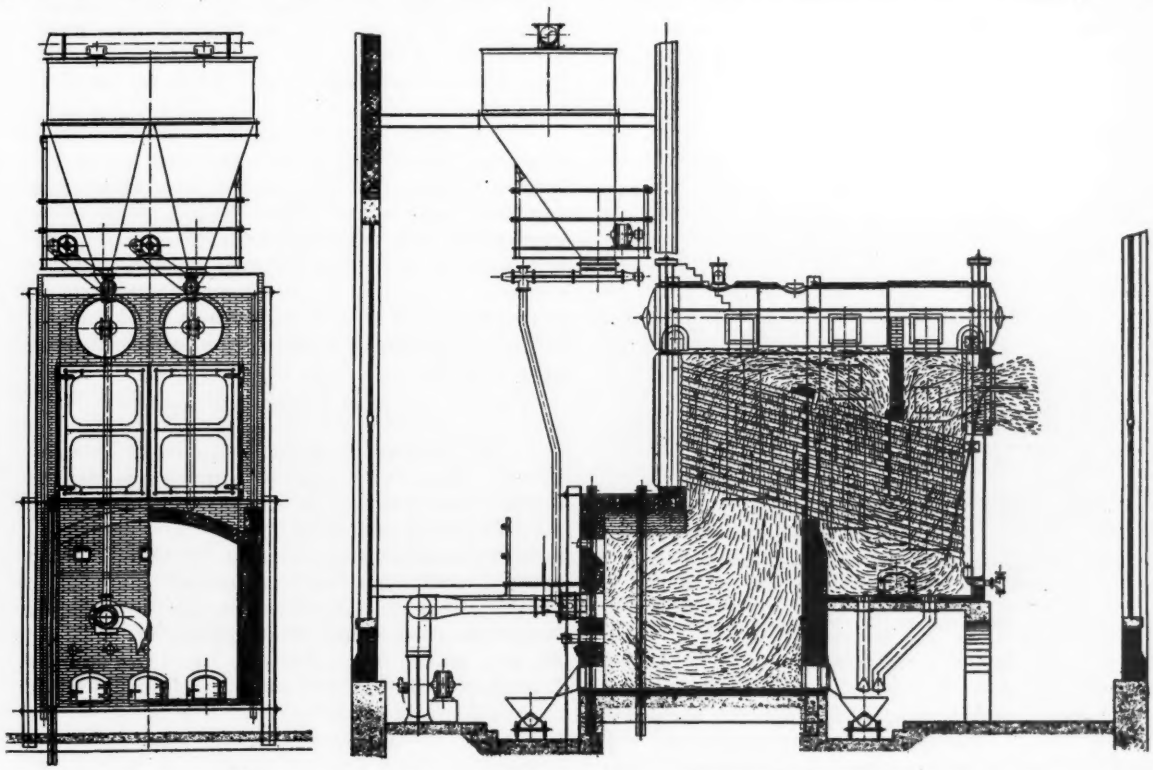
The paper presented by N. C. Harrison brought out several points not mentioned in the above abstract which are of particular interest to those in charge of operation. Relative to the quality of coal best suited for use in pulverized form he states:

"Practically any coal can be burned in pulverized form with a proper furnace and burning equipment. Each application, however, must necessarily be governed by the quality of the fuel available in the district in which it is made. Generally speaking, however, the coals which would give the most satisfactory results would be those in which the ash content would be less than 10 per cent, the volatile averaging between 30 and 40 per cent and the fixed carbon between 40 and 50 per cent. The sulphur content should be low, although coal with a sulphur content running as high as 4½ to 5 per cent is being burned in pulverized form under boilers without any detrimental results. The ash should have a high melting point. These statements, however, are tentative, as most excellent results have been obtained from all sorts of coals, differing widely from the ideal analysis stated.

"It is apparent that the development in this method of burning coal has brought coals, from which heretofore very inefficient results have been obtained, within reach of a great many consumers.

"From a technical standpoint pulverized coal is that coal which is properly dried, crushed and pulverized so that the product contains the highest percentage of impalpable powder. Merely powdering coal does not fulfill the requirements. Coal must be pulverized so that at least 95 per cent will pass through a 100-mesh sieve having 10,000 openings to the square inch, or in terms of dimension, 95 per cent must be less than 1/200 of an inch cube.

"Pulverizing certainly does not change the nature of the coal. We do, however, change the form of the coal to a certain extent in pulverizing it, in that we change it from a solid into a fuel having liquid properties. As the coal is pulverized it is mixed with air, and when handled in the conveyor it flows like water; when fed to the furnaces it is more or less like a gas, and the furnaces must be designed to burn a gaseous mixture.



500-HP. B. & W. BOILER, ARRANGED TO BE FIRED WITH PULVERIZED COAL

Costs of Pulverizing Coal

"The cost of the operation of pulverizing coal depends upon four items: first, the amount of moisture that must be expelled from the coal before pulverizing; second, the cost of labor; third, the cost of coal delivered at the pulverizing plant; fourth, the cost of electricity. The table shows actual costs at our plant.

Boilers

"In many of the earlier trials to burn pulverized coal under boilers the usual method was to install coal-feeding devices of some kind in the furnace as it stood, with the result that the fire bricks melted down and the tubes were plastered with unconsumed carbon, ashes and soot.

"For the proper combustion of coal under boilers, there are five main points which must be given serious

consideration, otherwise the burning of this fuel will not be a success. These five points are:

a. Coal fineness
b. Size of combustion chamber
c. Necessary air opening
d Proper damper regulation
e. Clean tubes

Coal Fineness

"The pulverized coal should run about 96 per cent through the 100-mesh screen and about 85 per cent through the 200-mesh screen. If it runs below 80 per cent through the 200-mesh screen, we notice particles of carbon flying through the air inside of the combustion chamber, and these particles are not completely burned when the gases reach the tubes, and will then deposit themselves on the tubes. Also, these heavy particles in the pulverized-coal mixture will sometimes settle on the bottom of the combustion chamber and will soon build up in the shape of stalactites. This accumulation will continue to build and the bottom of the combustion chamber continues to be raised, until it comes in contact with the flame. These built-up particles will then fuse into a solid mass, which, in a very short time, will cause a shut down of the boiler to dig this fused mass out. It is therefore necessary, for the successful burning of this pulverized fuel under boilers, to have this coal as finely pulverized as possible.

COSTS OF PULVERIZING COAL PER TON AT THE ATLANTIC STEEL COMPANY

Daily Output 80 Tons per Day

	Cost per ton
Labor	$0.22
Repairs	0.19
Power	0.134
Drier coal	0.0218
Total Cost	$0.5658

Daily Output 90 Tons per Day

Labor	$0.195
Repairs	0.19
Power	0.134
Drier coal	0.0218
Total Cost	$0.5408

Daily Output 100 Tons per Day

Labor	$0.176
Repairs	0.19
Power	0.134
Drier coal	0.0218
Total Cost	$0.5218

Total coal pulverized Jan. and Feb. 1919 ..... 5275 tons
Power: 17.9 kw-hr. per ton coal pulv. at ¼ cent ..... $0.134 per ton
Labor: 1 man 16 hr. at $0.40 ..... $ 6.40
2 men 16 hr. at $0.35 ..... 11.20
Daily cost $17.60
(= $0.22 for 80 tons output, $0.195 for 90 tons, $0.176 for 100 tons.)
Drier coal: Cost of drier fuel 2.8 cents per ton, based on 2.62 per cent moisture. Coal at $5 per ton, 6 lb. evaporated per lb. of coal burned or 8.7 lb. per ton of coal pulv.
Repairs: otal repairs for Jan. and Feb. $1412.16
Credit 409.69
Charged ..... $1002.47 (= $0.19 per ton pulv.)

Size of Combustion Chamber

"Before installing, or considering the use of pulverized coal under boilers, we must first make a study of our boiler-house installation and know at exactly what rating we wish to operate these boilers, considering any peak load which may develop. We must then design our combustion chamber large enough to take care of the maximum loads which will be developed from our boilers at any time. After this maximum rating has been determined, we then figure our combustion chamber of a cubical capacity equivalent to approximately 50 cu. ft. per lb. of coal burned per min., or approximately 2½ cu. ft. per hp. developed by boiler.

"If we decide to run this boiler at 150 per cent of this rating and design our combustion chamber accordingly, the efficiency will not be decreased perceptibly if the boiler is run under this 150 per cent rating, but if we develop over 150 per cent of the rating, we run into serious difficulties. We have to admit more coal and air to the boiler to develop the greater rating, consequently we need more combustion space, but not having this combustion space, the flames impinge on the brick work and cut it away very rapidly. Also, combustion is not complete at the time the gases strike the bottom row of tubes, and consequently the gases will pass up the stack unburned. Efficiency is then decreased.

"If the gases are not completely burned by the time they reach the first row of tubes, they will not burn later on in the boiler. The size of the combustion chamber should also be so designed that the velocity of the gases should not pass through this combustion chamber at a speed of more than 6 ft. per sec. The mixture of air and coal entering the combustion chamber, as stated above, should be at as low a pressure as is possible to bring this mixture in in suspension; or, in other words, breathe it in.

Proper Air Openings

"The pressure at which the pulverized coal is admitted to the furnace is as low a pressure as can be used to carry this fine coal in suspension, and is, I should say, about half an ounce pressure at the nozzle. In some installations the coal falls by gravity from the variable-speed screw conveyor, located on the bottom of the pulverized coal bin, into a fan air line which carries it into the furnace and also supplies the necessary air for combustion. Some few openings are placed in the front wall of the boiler to give any additional air which may be needed, and a few may also be placed on the side walls of the boiler to protect the brickwork at times.

"In other installations the amount of air necessary to convey the coal into the furnace varies, according to the rate at which the boiler is being operated. The balance of the air to burn the coal properly is admitted through adjustable air openings in the front, sides and bottom of the combustion chamber. These openings are made adjustable and are placed on all sides of the combustion chamber to take care of the various grades of coal which may be used in the boiler plant. By properly observing the combustion in this chamber, by a little experience the fireman knows at exactly what points to give more, or less air needed for combustion.

Damper Regulation

"In order to give the proper velocities of gases passing through the combustion chamber, it is necessary that we have very accurate damper regulation to take care of the various load conditions which the boiler is to supply. The damper should be so regulated that we should practically have a balanced draft inside of the

combustion chamber and only a slight vacuum in the first pass, while at the damper itself we do not want more than 0.10 to 0.15 in. If we have more vacuum than this, it pulls our gases through the combustion chamber too fast, causing them to be unburned before reaching the first row of tubes, and will then build up very fast on the outside of these tubes. This very small draft needed at the base of the stack will allow us to operate boilers using pulverized coal with stacks of about 30 to 35 ft. in height.

"The following few points must be kept in mind for the successful burning of pulverized coal under boilers:

"a. A boiler furnace using pulverized coal should have as few burners as is possible consistent with good regulation. The burners must be proportioned for the maximum rating of the boilers, and they must be adjustable. Simplicity of design is desirable. It has been found much more desirable to introduce coal into the furnace as far away from the side walls as possible so that the rapid continuous expansion of the gases will not develop high velocities in close contact with the furnace refractories. Furnaces under boilers should be proportioned so that the velocity of the gases should not be excessive, particularly at the smallest cross-sectional area of the furnace. Vertical baffles should replace all horizontal baffles.

"b. A boiler of any size can be fired successfully with pulverized coal. Various designs and makes of boilers can be readily arranged for pulverized-coal firing, but those containing the smaller percentage of space for the lodgment of ash are preferable.

"c. Feeders for regulating the flow of pulverized coal to the furnace must be designed so that at all times the variation in quantity will be directly proportional to the speed of the screw and no flooding allowed. The speed of the feeder should be so regulated that operating at its maximum r.p.m. the supply of pulverized coal to the furnace will not exceed the capacity of the furnace. Soot blowers should be installed in settings where pulverized coal is used.

"d. The equipment for using pulverized coal is standard for any grade of coal so far as handling, preparing and delivering to the furnace is concerned. Only a slight change is necessary in the furnace to take care of coals of very low volatile content, such as anthracite, culm and coke breeze, and increased drying capacity is desirable when lignite coal is used."

In discussing Mr. Harrison's paper Albert A. Cary expressed the opinion that many are overoptimistic in regard to pulverized coal, regarding it as having almost unlimited possibilities for all kinds of furnace applications and capable of easily and cheaply accomplishing phenomenal results. He pointed out that many failures have marked the path of the progress in the use of this form of fuel during nearly a century of development. His evident faith in this method of using coal is, however, brought out in the following statement:

"I am an unqualified advocate for the use of such fuel, but I certainly limit my endorsement to applications where a desirable grade of fuel is available; where proper preparation of the fuel and proper furnace conditions can be obtained and where other methods for burning the available fuel are inferior, to accomplish the desired heating."

Continuing his attitude of conservatism Mr. Cary's remarks on this form of fuel in power plants are as follows:

"The application of pulverized coal fuel to steam boiler furnaces meets with many challenging difficulties to be overcome. Otherwise the many earnest and costly attempts made during the past 60 or more years might, long ago, have made pulverized coal a widely used boiler fuel. Recent developments have done much to overcome difficulties formerly experienced with the use of pulverized coal in stationary boiler plants, and consequently we find, today, a number of such installations in use, some of them showing very desirable economy and producing a material increase in the steaming capacity of the boilers. A few of such installations have been made in central power stations where the result of their experience is being watched with much interest.

"The cost of a milling plant, for properly drying and pulverizing the coal, as well as the space required for its installation, often proves an obstacle for the installation of such equipments in power plants.

"Mr. Harrison has very tritely stated that 'the finer the coal is pulverized the more efficiently it can be burned.' We can readily understand the reason for this statement.

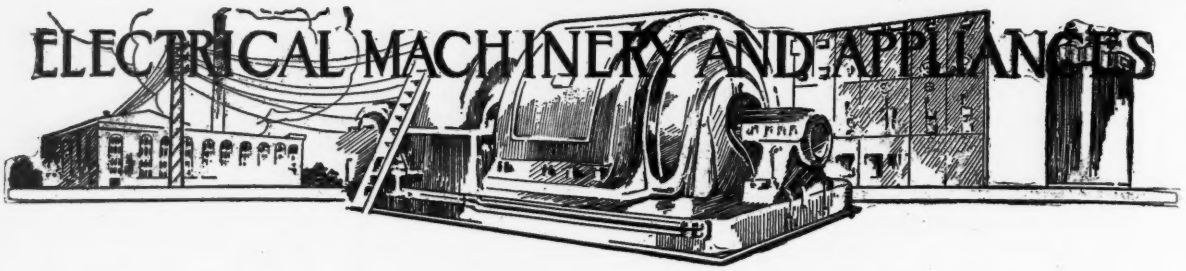
"Uniformity in the size of pulverized particles is also very desirable, as we can readily understand that if we have mixed a considerable percentage of different sizes of coal fed to our furnaces the combustion of the larger size will proceed much slower than the burning of the smaller size, which condition not only reduces the velocity of combustion to the total mass, but it prevents the production of a 'gaslike flame.'

"When such grades of coal, averaging from 30 to 40 per cent of volatile matter, as described above, are pulverized so that over 90 per cent will pass through a 200-mesh screen, the finer coal accompanying it does not seem materially to affect its even rapid burning effect in general furnace practice, and further, with this very fine pulverization, which insures rapid and high temperature combustion, the sulphur in the coal burns rapidly to SO_2 gas, which passes to the stack without affecting the product of the reverberatory furnace.

"When a coal, running high in fixed carbon, is used as pulverized fuel, we have a different and less desirable set of furnace conditions.

"Lacking the production of an ample supply of volatile combustible gases given off by the coal at a comparatively low temperature, and also lacking the heating effect which the burning of these gases produces, to hasten the combustion of the associated fixed carbon, and to obtain the best possible results, the coal should be ground finer, as it will be found that this fuel is slower to ignite. Much of such coal carries a higher ash content, which still further complicates matters and lowers the heat value of the coal."

In the general discussion it was brought out that in the Detroit plant, which is stoker-fired, the running over-all efficiency of the boilers is in the neighborhood of 75 per cent, that the power for driving the stoker is 1 per cent of the power developed, and for the fans is less than 2 per cent. The excess air used in the furnace is 10 to 12 per cent, which is considerably less than average good practice throughout the country.



A Study of Dynamo Electric Machinery---V

SHUNT AND COMPOUND WOUND GENERATORS; THEIR THEORY OF OPERATION, CHARACTERISTICS AND APPLICATION. BY OTTOMAR H. HENSCHEL

IN the series-wound machine in which the field winding is connected in series with the armature, increase of current flow reacts upon the field, strengthening it and thereby providing increased electromotive force. In other words, with speed remaining fixed, the electromotive force induced within the armature winding varies as the flow of current through the field coils.

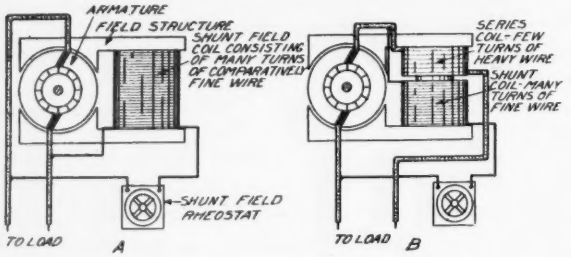


FIG. 24. GENERAL ARRANGEMENTS AND SCHEMES OF CONNECTIONS OF (A) SHUNT-WOUND AND (B) COMPOUND-WOUND MACHINES

If the field is made up of a highly magnetized permanent magnet (such as used in magnetos), the electromotive force produced is dependent upon the speed of the armature and if that remains unchanged, the electromotive force remains unchanged. A constant electromotive force or voltage is produced and the machine is termed a constant voltage or constant potential generator. The use of permanent magnets is, however, impracticable and in order to provide a so-called constant voltage or potential, the shunt-wound machine as shown at (A) Fig. 24, was devised. In this type of generator the line leads connect directly with the brushes and instead of all of the line current passing through the field winding, but a small part of that delivered by the armature is utilized for the purpose of excitation.

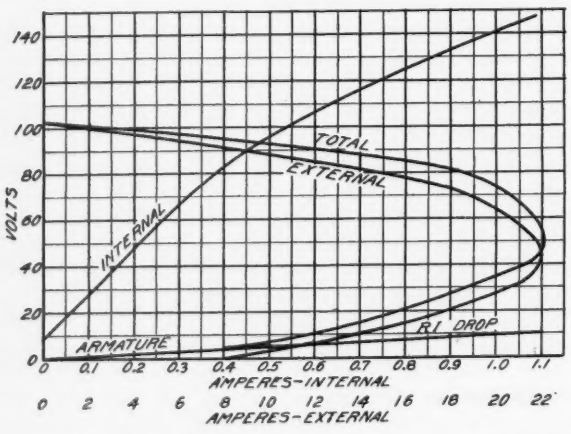


FIG. 25. CHARACTERISTIC CURVES OF A SHUNT-WOUND GENERATOR

As the armature is set in rotation, due to the residual magnetism of the field, a slight electromotive force is created which forces a small current through the field winding with the consequence that the magnetomotive force and the resulting magnetic flux are increased, thus aiding in the building up of the voltage. With increased speed a greater electromotive force is produced, more current is caused to flow through the field winding and the voltage continues to rise in value. With the armature rotating at its rated speed and other conditions remaining unchanged, the field strength remains fixed and as the resistance of the winding remains constant the field strength and consequently the voltage can only be altered by the use of a variable resistance or rheostat, connected as shown at (A) Fig. 24. If, therefore, the speed of a shunt-wound generator is constant, and its load remains fixed, the electromotive force of such a machine can be varied only by changing the resistance of the shunt field winding circuit, that is by altering

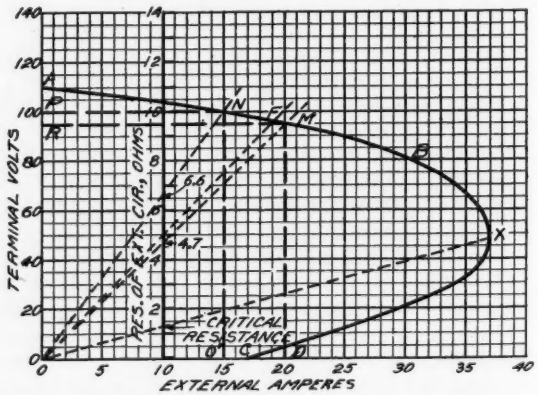


FIG. 26. CHARACTERISTIC CURVE OF A SMALL SHUNT-WOUND GENERATOR AND METHOD OF OBTAINING RESISTANCE OF EXTERNAL CIRCUIT

the setting of the rheostat. Increasing the reesistance will lower the electromotive force while decreasing the resistance causes a rise in voltage.

Effect of Armature Drop on Voltage

If, however, the load on the generator increases, more current will flow through the winding of the armature; and although (assuming the field strength to remain constant) the electromotive force induced in the conductors of the armature is of fixed value, the terminal voltage due to the R I drop will decrease. This in turn will decrease the flow of current through the field winding, the field will weaken, and a further drop of voltage will result. With added load, this action will cause a continued drop in terminal electromotive force and if the load (current flow through armature) is excessive, the machine will "unbuild" or demagnetize and the voltage as indicated in Fig. 25 will tend to drop to zero; practically, it does not do so, however, owing to residual magnetism.

That external circuit resistance which is low enough to cause a shunt generator to demagnetize thus rapidly

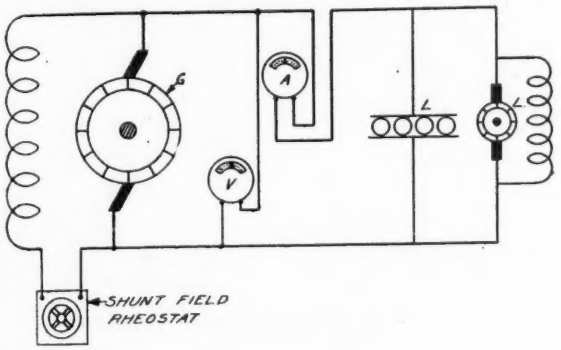


FIG. 27. SCHEME OF CONNECTION AND ARRANGEMENT OF INSTRUMENTS EMPLOYED TO OBTAIN EXTERNAL CHARCTERISTICS OF SHUNT-WOUND GENERATOR

is termed the critical resistance for that particular machine.

Characteristic Curves and Determination of External Circuit Resistance

Three characteristic curves are to be considered, the external, the internal and the total. The first of these is that in which the terminal volts are plotted against the amperes flow through the external circuit and as shown in Fig. 25, consists of a loop. Starting at maximum voltage and zero current, it follows a gradually sloping path, when suddenly it turns, doubles back and tends to approach zero-zero.

The internal characteristic taken by plotting terminal volts against the amperes in the shunt circuit (with outside circuit open) is like the curve for a series machine. It rises steeply at first and then bends over as the saturation of the field cores becomes noticeable.

To obtain the total characteristic curve the total volts generated by the machine are plotted against the total current. This curve may, however, be obtained in another way, knowing the resistance of the armature winding plot an armature R I drop curve, such as shown in Fig. 25, the various points for such a curve being obtained by multiplying the resistance of the armature winding in ohms by the flow of current in the armature in amperes. Adding to the external characteristic curve, corresponding value of armature R I drop will produce the total characteristic curve.

Shown in Fig. 26 is the external characteristic curve of a typical small shunt-wound generator, obtained by plotting instantaneous readings of instruments connected

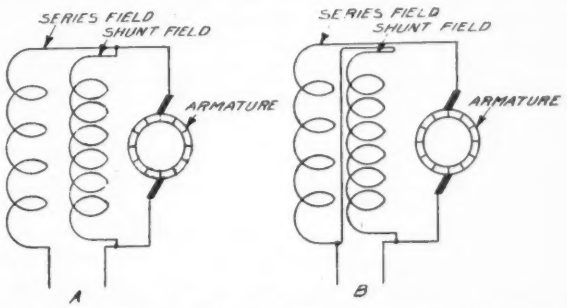


FIG. 28. DIAGRAMMATIC REPRESENTATION OF (A) SHORT AND (B) LONG SHUNT-COMPOUND-WOUND GENERATOR

as indicated in Fig. 27, G is the generator, A an ammeter, V a voltmeter and L the load. As the load increases, that is as more resistance is connected in parallel across the main lines, the total resistance of the external circuit decreases and as a consequence an increased flow of current takes place. In other words, as the external resistance decreases, the current flow increases, and as the instantaneous ammeter and voltmeter readings are obtainable throughout the range of rated capacity, the value of the external resistance at any point of the external characteristic may be readily determined by the application of Ohm's Law. The resistance of any circuit is equal to the applied electromotive force in volts divided by the current in amperes.

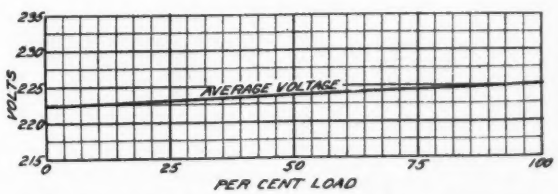


FIG. 29. CHARACTERISTICS OF A TYPICAL OVER-COMPOUND-WOUND GENERATOR

Referring to Fig. 26, we find that with a flow of 15 amp. through the external circuit the terminal voltage is 100 and that the value of the external resistance corresponding to point N (the intersection of O′ N and P N) is equal to 100 divided by 15, or 6.6 ohms. Similarly, the voltage with a flow of 20 amp. is 95 and the resistance of the external circuit corresponding to point M (the intersection of Q M and R M) is equal to 95 divided by 20, or 4.7 ohms.

Having plotted the characteristic curve of any shunt-wound generator, a scale may be incorporated by means of which the value of the resistance of the external circuit (expressed in ohms) corresponding to any point on the characteristic curve is readily obtainable. This scale

may be erected at any point although for convenience the 10-amp. ordinate has been selected, and it is obvious that by drawing O N the point of intersection of this with the vertical ordinate locates the point representing 6.6 ohms. In a like manner, the point representing 4.7 ohms is at the intersection of O M and the vertical ordinate.

Again referring to Ohm's Law, we find the value of electromotive force in volts equal to the product of the resistance in ohms and the current in amperes. With the particular setting chosen, the current is 10 amp. and with an assumed resistance of 2 ohms, we find the value

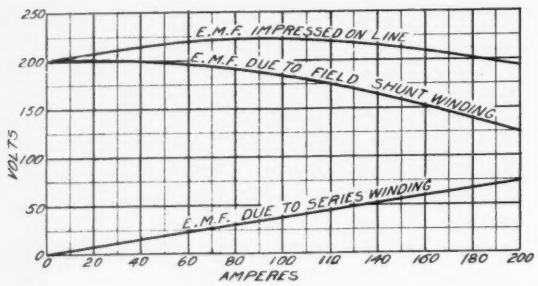


FIG. 30. CHARACTERISTICS OF A TYPICAL FLAT COMPOUND-WOUND GENERATOR

of the electromotive force equal to 2 times 10 or 20 volts; when the resistance is 4 ohms the corresponding electromotive force is 40 v. When 8 ohms the electromotive force is 80 v. and so on.

Having erected and completed the scale, the value of the resistance of the external circuit corresponding to any point on the characteristic curve such as let us say F, may be determined by running a straight line from the origin (or zero-zero) to point F. The reading of the resistance scale at the point of intersection of O F is the value of the resistance of the external circuit, in this particular instance 5.

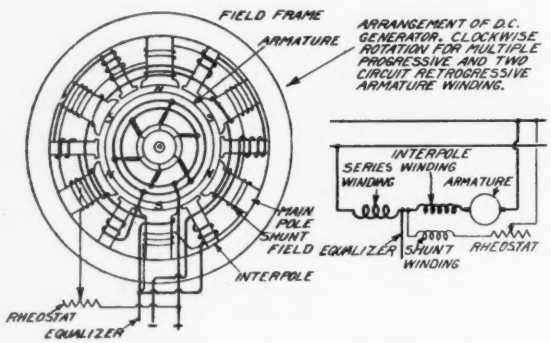


FIG. 31. INTERPOLE GENERATOR DIAGRAMS

X in Fig. 26 is the knee of the characteristic curve and indicates the maximum load the machine will carry before demagnetization. Joining this point with zero-zero, we have O X, the intersection of which with the resistance scale indicates the critical resistance of the particular generator to be approximately 1.25 ohms.

The critical resistance of any shunt-wound generator is that resistance of the external circuit which will cause the generator to unbuild or demagnetize.

Application of Shunt Machines

Within a limited range of load the shunt-wound generator is essentially a constant voltage machine. It is used to but a limited extent at the present time because of the more satisfactory results obtainable by the employment of compound-wound generators.

Compound-Wound Machines

In the case of series-wound machines, increase of load results in increase of field magnetization and as a result the voltage will tend to rise while with the shunt-wound generator as just explained, the voltage due primarily to the armature R I drop, has a tendency to decrease in value. It is obvious, therefore, that due to these characteristics, series and shunt-wound machines are not, unless provided with more or less elaborate regulating devices, capable of maintaining constant voltage throughout the range of their rated capacities.

If, however, the pole pieces of a generator are provided with two sets of windings, one as in the case of the series machine, made up of a comparatively small number of turns of heavy wire and connected in series with the armature, and the other made up of a large

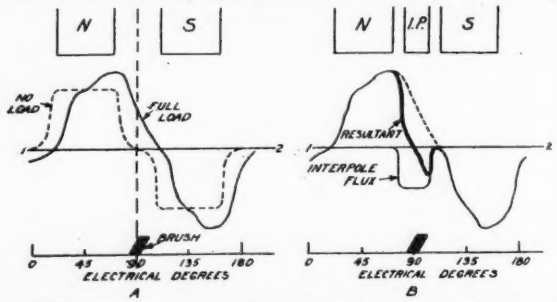


FIG. 32. EFFECT OF INTERPOLE UPON GENERATOR FIELD

number of turns of fine wire connected as in the case of the shunt generator across the armature, the characteristics of the machine will naturally be a combination of those of a series and a shunt-wound generator. Machines so fitted with shunt and series windings are known as compound-wound generators, and by properly proportioning the number of series and the number of shunt winding turns, the terminal voltage may be made to remain practically constant throughout a wide range of load, or if so desired the voltage may be made to increase slightly with increase of load. Machines in which the voltage is maintained practically constant are generally referred to as flat compound-wound generators, while those given a rising characteristic are termed over-compound-wound generators.

The degree of overcompounding ordinarily employed is such as to provide a full load terminal voltage of from 2 to 12 per cent in excess of the no-load terminal voltage.

Schemes of connections of compound-wound generators are shown in Fig. 28, that at A, where the shunt widing is connected directly across the armature, being known as the ordinary or short shunt connection, while that at B, where the shunt winding is in series with the series coil is the so-called long-shunt compound-wound generator. Due to the comparatively low resistance of the series field winding, there is but little difference in the performance of short and long-shunt-connected compound-wound generators.

Characteristics of over and flat compound-wound machines are illustrated in Figs. 29 and 30 respectively.

Application

Compound-wound generators are now used almost exclusively for direct current light and power service and where such machines feed long lines along which the voltage drop is considerable, and it is desired to maintain machine voltage at point of utilization, over-compound generators are of considerable value.

Compound-wound generators are also extensively employed as exciters for alternating-current generators.

Interpoles and Compensating Windings

In the ordinary direct-current generator carrying excessive loads more or less difficulty is encountered with the sparking of the brushes where they make contact with the commutator. This is attributable to the fact that, as the flow of current through the armature winding exceeds its nominal value, excessive distortion of the field will result and as a consequence the armature coils in which reversal of direction of induced electromotive force is taking place are no longer short-circuited by the brushes. Instead, however, the brushes are short circuiting coils in which a continuous electromotive force is being induced, thus causing sparking detrimental to both brush and commutator.

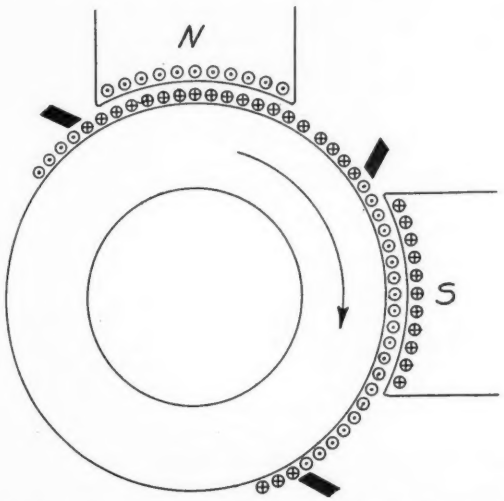


FIG. 33. ARRANGEMENTS OF COMPENSATING WINDINGS

To prevent this action and to insure sparkless commutation under all conditions of operation, many generators are provided with auxiliary poles called interpoles and placed midway between the main pole pieces as indicated in Fig. 31. The windings on these poles, which are connected in series with the artmature, establish within the cores a magnetic flux, which opposes the armature current field and of such value and direction as to produce within the coil or coils being short-circuited by the brushes, an electromotive force, which will insure reversal of the current in such coil or coils, while still under the brush.

In the case of generators, interpole connections are made such as to provide an interpole polarity the same as that of the following main pole. The interpole ampere-turns per pole for a newly designed machine are usually made equal to 1.4 times the armature ampere-turns per pole. This is, however, as a rule too large, so adjustment must be made with a shunt after the machine is erected.

The effect of interpoles upon the magnetic field of a generator is shown in Fig. 32. With no current flow through the armature, a graphical representation of the magnetic flux of two adjacent pole pieces would be as indicated by the dotted line at A, while with the distortion due to armature reaction, the curve would assume the form shown by the full line. As will be noted, unless the brush be shifted forward, this line crosses the neutral axis at some point beyond that at which the dotted line crosses, and as a consequence sparking will result as explained. If, however, an interpole is placed between the two main poles in the manner indicated at B, Fig. 32, the curve representing the resultant field will cross the horizontal axis 1—2, where this intersects the line midway between the two main pole pieces. In this way, are the coils short-circuited by the brushes retained within that part of the field in which the direction of electromotive force is reversed, and sparkless commutation thereby assured.

Another means by which armature reaction may be reduce is by the employment of so-called compensating windings, which consist of a layer of wires, parallel to the armature shaft, embedded in the pole forces as shown in Fig. 33. This winding is so connected that all or a part of the armature current flows through each wire as indicated by the dots and crosses.

Why Disconnect Switches Open On Short Circuits*

By Terrell Croft

DISCONNECT switches are frequently thrown open when a short circuit occurs on the lines connected to them, because of the magnetic reaction of the field generated by the current passing through the switch.

During normal operation the current through the switch is so small, relatively, that the magnetic field generated around the switch is not of sufficient strength to make the switch open. At a time when an external wire is short-circuited, however, the current through the switch may be increased to many times its normal value. It is then that the magnetic reactions generated by this current are sufficient to throw the switch open.

A magnetic field of circular lines of force establishes around every conductor through which an electric current is flowing. In Fig. 1 is indicated in a rough way how these circular lines of force establish around the ring-shaped conductor ABCD. Now, due to the interaction of these circular lines of force, there is always a longitudinal tension along a conductor carrying current. There is also a transverse compression; that is, the lines of force act like taut rubber bands. They tend to shorten themselves in the direction of their length. Furthermore, they tend to crowd away, longitudinally, adjacent lines. Because of this phenomenon, every conductor which has a shape approximating a ring tends to

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enlarge so as to inclose a maximum number of lines of force. For example, the tendency of the conductor ABCD of Fig. 1 is to enlarge into a shape EFGH so as to inclose more lines.

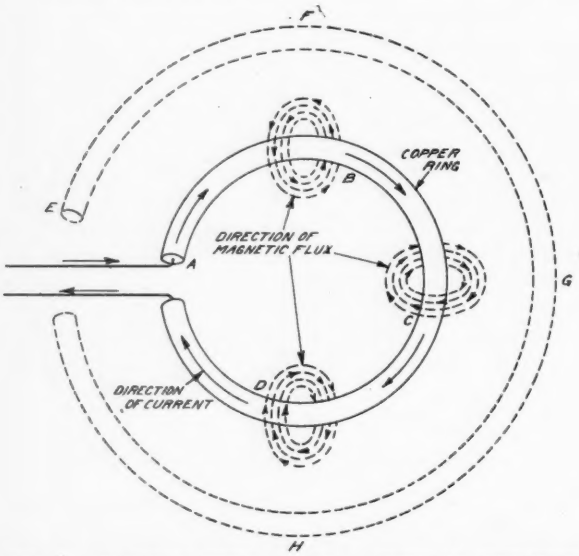


FIG. 1. MAGNETIC FIELD ABOUT A CIRCULAR CONDUCTOR

Obviously such an enlargement is impossible under ordinary conditions because the tensile strength of the metal of the conductor is sufficient to prevent such enlargement.

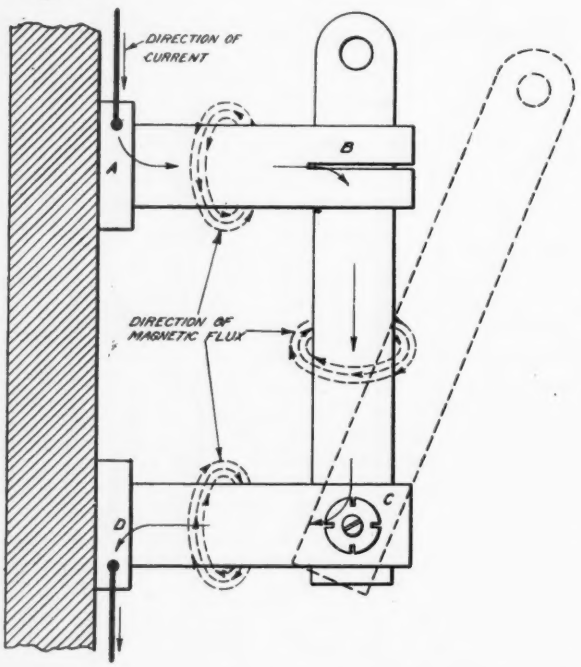


FIG. 2. MAGNETIC FIELD ABOUT A DISCONNECT SWITCH

If, however, we now consider a disconnect switch as shown in Fig. 2, it is evident that when the blade is thrown from the position BC toward the position EC the conducting portion ABCD will inclose a greater field. The phenomenon illustrated in Fig. 2 is precisely what occurs when a short-circuit current throws open a disconnecting switch. A short-circuit current, which is many times normal value, establishes about the conducting part of the switch ABCD circular fields of force, and it is due to the interaction of these—that is, to the fact that the tendency of every conductor carrying current is to inclose a maximum number of lines of force—that the switch is thrown open.

To prevent the accidental opening of disconnect switches it is modern practice to supply them with latches which must be released by the attendant before the switch can be opened. A disconnect switch with one of these latching arrangements is illustrated in Fig. 3.

The distortion of bus structures that sometimes occurs when a line is short-circuited is due to magnetic action similar to those that occur when a disconnecting switch is thrown open.

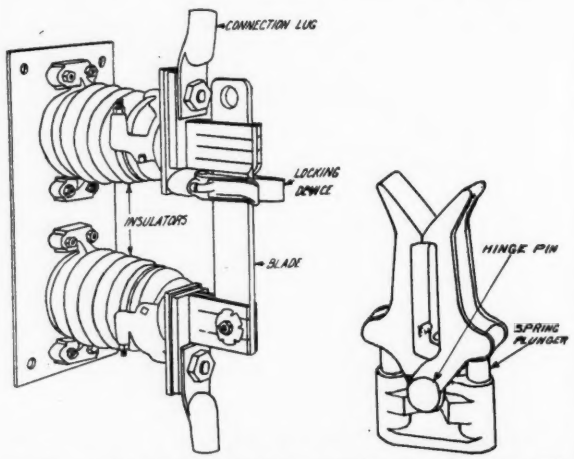


FIG. 3. CATCH ON DISCONNECT SWITCH TO PREVENT ACCIDENTAL OPENING

As to the methods of correcting the difficulties caused by these excessive magnetic interactions, it is evident that all of them are due primarily to excessive currents. It follows, then, that any expedient which will prevent the possibility of excessive currents through the bus structures in disconnect switches will prevent their accidental distortion.

The current through the lines and bus structures of a central station can be limited by inserting reactance coils, or, as they are called commercially, "current limiting reactances," at proper locations in the circuits. Inasmuch as the average drop across these reactances is largely inductive, little real power is expended when current passes through them.

At the same time, the reactances will limit the current that flows when a short circuit occurs, and thus protect all of the central station apparatus.

LIMITATION of the cotton planting in southern states was reported in the spring to be practiced by general agreement, according to the July 1 forecast of the Department of Agriculture in a crop 1,000,000 bales smaller than last year. This leaves little hope for lower prices of cotton goods for at least another 12 mo.

The Diesel Engine---I*

COMPARATIVE ECONOMIES; SOME STRUCTURAL DETAILS. BY HERBERT HAAS

THE USE of explosion oil engines should be dictated entirely by their over-all economy. Although they are materially cheaper in first cost, they consume considerably more fuel and lubricating oil than Diesel engines, and their fuel consumption at fractional loads increases at a greater rate than does that of Diesel engines.

The difference in economy between explosion oil engines and Diesel engines is due not so much to a difference in thermodynamic cycles as in constructional differences, which decidedly favor the Diesel engines.

The higher the initial temperature and the lower the terminal temperature the more perfect will be the heat utilization. High initial temperature is a function of pressure. If the compression were carried as high in the explosion engine as in the Diesel, the explosion oil engine theoretically would show a slightly higher thermo-dynamic efficiency than the Diesel engine. The final pressure, when the fuel is burned at constant volume, would, however, be greatly increased above the compression pressure, or to about 60 atmospheres, with an accompanying rise in temperature far beyond that practicable with the materials of construction available. These limitations impose a lower compression pressure on explosion oil engines than on Diesel engines, so as to keep the maximum pressure and temperature within safe limits of permissible engine construction.

Thus with a compression pressure of 150 to 250 lb. per square inch the explosion pressure becomes 270 to 500 lb. per square inch; and with the instant ignition and burning of the previously vaporized oil common to explosion oil engines, a temperature of 2300 to 3150 deg. F. is reached.

The Diesel engine has a higher but more gradually increasing compression pressure (450 to 500 lb. per square inch) which does not subject the engine to sudden shocks, with a resulting increase in temperature from atmospheric to about 1000 deg. F. The fuel is gradually injected as the piston moves from its top center (inner dead center) downward, the pressure remaining practically constant during the time of fuel admission. With a decrease in load, the time of fuel admission is also shortened, that is, the fuel supply is shut off sooner. Therefore the increase in temperature due to the burning of the fuel at constant pressure does not exceed that reached in an explosion engine, notwithstanding the higher compression pressure used in the Diesel engine, and the higher initial temperature caused by this compression. Thus, the temperature in a Diesel engine seldom exceeds 2600 deg. F., and reaches 3000 deg. F. only when the engine is overloaded.

If, then, the working cycles of the two types of engines are compared on the basis of compression pressures used, the Diesel engine is found to have a greater thermal efficiency, because it can work successfully with the higher compression pressure.

COMPARATIVE ECONOMIES OF DIESEL AND OF EXPLOSION OIL ENGINES

	Diesel engine, European (a)				Diesel engine, American (a)				Explosion oil engine, European (b)				Explosion oil engine, American (b)			
	Load.	Fuel per hp.	Per cent.	Barrels per year	Fuel cost per hp.-year (8760 hp.-hours	Load	Fuel per hp.	Per cent.	Barrels per year	Fuel cost per hp.-year (8760 hp.-hr.	Load	Fuel per hp.	Per cent.	Barrels per year	Fuel cost per hp.-year (8760 hp.-hours).	Load	Fuel per hp.	Per cent.	Barrels per year	Fuel cost per hp.-year (8760 hp.-hours).
		Lbs.					Lbs.					Lbs.					Lbs.			
Fuel consumption or cost at different loads	4/4	0.42	100	863	$11.80	4/4	0.48	100	986	13.15	4/4	0.60	100	1,232	$16.43	4/4	0.75	100	1,540	$20.55
	3/4	.44	104.8	678	12.05	3/4	.50	104.2	770	13.68	3/4	.65	108.3	1,013	18.11	3/4	.83	110.7	1,280	22.76
	1/4	.50	119	685	13.70	2/4	.58	120.8	610	16.27	2/4	.75	125	770	20.53	2/4	.95	126.7	975	26.00
Oil consumed for lubrication, gal lons per year.	360 to 550					360 to 550					1,100 to 1,460					1,100 to 1,460				
Cost of lubrication.	$128 to $193 per year, or $1.70 to $2.60 per horsepower-year.					$128 to $193 per year, or $1.70 to $2.60 per horsepower-year.					$380 to $510 per year or $5.10 to $6.80 per horsepower year.					$380 to $510 per year or $5.10 to $6.80 per horsepower year.				
Cost of installation, including building.	$90 per horsepower					$90 per horsepower					$60 per horsepower					$60 per horsepower				

a 75-hp., one cylinder, single-acting engine having a four stroke cycle.
b 75-hp., two cylinder, single-acting engine having a two stroke cycle

Comparative economies of Diesel and of explosion oil engines are shown in the table. On a basis of oil costing $1 a barrel, the minimum yearly fuel cost in dollars corresponds to the number of barrels of oil consumed yearly. Oil usually costs more than $1 a barrel, especially gas oils, which are the only oils suitable for use in explosion oil engines. On the other hand, residues and heavy fuel oils can be burned in the Diesel engine. Lubricating expense is also materially higher in explosion than in Diesel engines. With a fairly good load factor it will not take long to make up the difference in first cost by greater economy, particularly when the fuel cost is increased by long hauls.

DETAILS OF DIESEL ENGINES

DIESEL ENGINES are built in both vertical and horizontal units, each type showing some differences in construction in the frame, the valve gear, the fuel injector and the lubricating arrangements.

Vertical engines are built as one cylinder and as

* Abstract of Bulletin 156 of the Department of the Interior, Bureau of Mines.

multicylinder units. The details of the bed-plates of such engines vary according to whether they are to support the closed crank case or individual cylinder frames, so-called A frames. For supporting the closed crank case the entire top joint of the bedplate is planed to insure an oil-tight joint between it and the crank case; for supporting individual cylinder frames the bed is provided with carefully machined pads or surfaces to which the A frames are bolted. The bed is cast integral with the crank pit and the seats to receive the main-shaft bearings. The pit is as a rule used as a reservoir for collecting the spilled and surplus lubricating oil.

The choice of individual cylinder frames enables the manufacturer to build with greater ease two, three, four, or even five and six cylinder units from a smaller number of standardized cylinders and valve gears. With an engine having a closed crank case this is not so readily and cheaply accomplished. Inasmuch as most engines are used for the generation of electric current with direct-connected generators, four-cylinder units are necessary to obtain the desired cyclic regularity for satisfactory generator performance in engines having four-stroke cycle, especially when two or more units are to operate in parallel. Multicylinder units also permit a higher number of revolutions, by shortening the stroke without necessarily increasing the piston speed of these units. Such features combine to produce a compact, relatively light engine. The closed crank case is the construction favored for medium and high speed engines, with which forced-feed lubrication is used. There is no spilling and spattering of lubricating oil, and the engine and engine-room floor are readily kept clean. The forced-feed lubricating system, at first used only on high-speed units, has proved so satisfactory and so economical in the use of lubricants that it is used increasingly on medium-speed and low-speed engines. In Europe manufacturers have adopted this closed crank case construction for units up to 1000 hp.

In larger engines, which require the use of A frames, the panels are connected with steel sheets provided with large doors between the individual frames, so as to obtain the advantages of a closed crank case and of forced-feed lubrication.

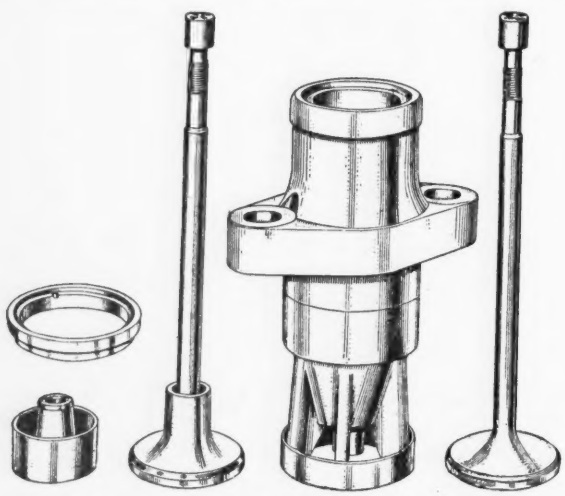


FIG. 1. DIESEL ENGINE VALVES AND VALVE FITTINGS

On the bedplate is also mounted the multistage air compressor, usually in a vertical position to preserve the symmetry of the engine.

Air Inlet and Exhaust Valves

Air inlet and exhaust valves (Fig. 1) are usually housed in flanged cages bolted to the cylinder head. A cage contains the valve seat and the valve-stem guide. The upper part of the barrel is machined and serves to guide the carefully centered spring cap. The latter is screwed to the valve stem and holds the spring in place. The valves are generally made of cast iron, the stem being of steel. It is usual practice to provide valves, except those of the smallest size, with removable valve seats. Air and exhaust valves seldom differ, except that for engines with more than 30 or 35 hp. per cylinder the valve-stem guide is water-cooled. Four-stroke engines are seldom built in sizes requiring the water-cooling of the exhaust valves, and two-stroke engines exhaust through ports uncovered by the piston.

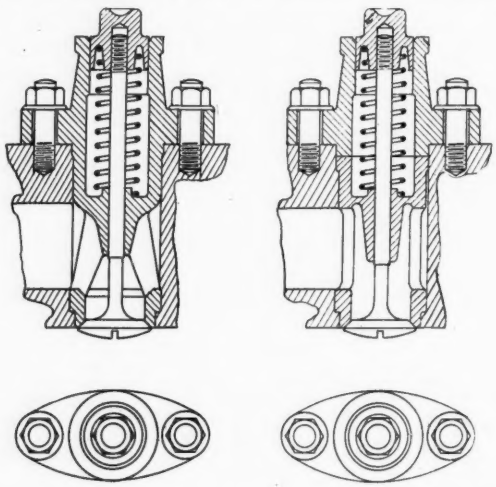


FIG. 2. CUSTOMARY VALVE CONSTRUCTION OF DIESEL ENGINE

Figure 2 shows the customary valve construction. The spring cap has a concave depression, into which the jointed ball of the actuating lever fits.

In engines fitted with gas-engine heads, the usual practice is to house only the air valve (placed in the top of the head) in a cage. After the air valve with cage has been removed, the exhaust-valve stem, disc, and seat are accessible through the opening in the air-valve cage and can be removed through it. In two-cycle engines with gas-engine head, only the scavenging valves are in the head, and are on its top and bottom, one directly above the other. In this type the valves are similar and are housed in cages. The disc is provided with two holes for the insertion of a special key, or the valve stem is slotted so that a bar can be inserted, for turning the valve disc back and forth; a small amount of emery dust and oil is used in grinding.

The starting valve admits air under high pressure (500 to 600 lb. per square inch) into the engine cylinder whenever the engine is started. Hence the valve disc must seat perfectly to prevent air leakage when the valve is closed. It is usually constructed as a balanced valve; a part of the valve stem is enlarged

and provided with packing rings, the air admitted pressing equally on both sides of this piston. A strong spring insures the tight seating of the valve.

Some engines are equipped to start with air at a pressure of about 250 lb. per square inch. The starting valve is fitted with a plunger that closes the valve as soon as the cylinder pressure exceeds that of the air used for starting.

Fuel Valves

The fuel-injection valve is an important and characteristic part of a Diesel engine, and on its correct construction greatly depends the satisfactory operation of the engine. It performs two distinct functions. First, it has to admit the liquid fuel into the engine cylinder at the proper time, and must therefore be an accurately timed valve. Second, it has to introduce the liquid fuel into the cylinder in a completely atomized form, and must therefore be an efficient atomizer.

The first requirement is fulfilled by storing around the tip of the fuel needle a drop of oil, which is forced ahead of the injection air into the heated atmosphere of the engine cylinder at regularly recurring intervals, and thus initiates the ignition. The second requirement is accomplished by dividing the fuel supply into numerous small fuel particles in the fuel valve, preceding atomization and injection.

(To be continued)

Industrial Safety---I

Design and Construction of Safeguards*

By R. J. Young

A SAFEGUARD should be so designed and constructed that it will prevent *all* accidents on the part guarded—not only accidents to the operator while at his regular work, but also to the operator or passers-by in case they slip or fall or carelessly touch the machine.

The guard should not interfere with production. If it does, it is liable to be taken off. In designing a guard it is generally wise to consult the man who will use it.

In general, the guard should be attached to the machine and not to the floor; if attached to the floor, use a connection which will interfere as little as possible (see drawing).

The guarded part must be easily accessible for oiling, inspection, and repair. The door or removable section provided for this purpose should be hinged or otherwise attached to the remainder of the guard, or to the machine. If not, it is likely to be left off permanently.

The guard should not interfere with cleaning and sweeping around the machine. It should, therefore, be kept generally about 6 in. above the floor.

The guard should be strong enough to resist injury and keep its shape. A light, flimsy guard soon becomes bent and is discarded. A substantial guard is cheaper in the end.

Incombustible guards are preferred. Wooden guards, soaked with oil, may become a serious fire hazard. Metal guards are neater and wear much better. "Metal guards look as if you wanted to; wooden guards look as if you had to." Guards may be made of cast iron, sheet metal, or slats. Where subjected to acid or fumes, wooden guards may be necessary.

It is desirable to interlock the guard with the operating mechanism, where possible, so the machine cannot be operated unless the guard is in place.

A safeguard can often be so designed that it will also serve to prevent wear on the parts guarded—for example, a solid gear enclosure.

A few typical guards, embodying these principles, will now be described.

Transmission

All gears, wherever situated, should be guarded. Cast-iron guards are preferable because they may be made to fit more snugly, present a better appearance, and protect the gears from dust and injury. In shops having similar gears on several machines, the cost of patterns and cast iron guards will be no greater than the cost of "built-up" guards. A cast guard of one machine may be used as a pattern for making guards for similar machines.

Guards for a variety of machines, and in many sizes, may be more cheaply made of sheet metal. In large guards, an angle iron is used to make the joint between the flat sides and the curved part of the guard. In smaller guards this joint may be made by cutting projections (like saw teeth) on each side piece and bending these over to form a smooth curve. The joint may then be made either by spot welding or by riveting. Short pieces of angle iron may also be used to form the joint—about ¾ by ¾ by ⅛-in. angles, one inch long, 3 or 4 in. apart.

Gears should be completely encased; or, where this is impracticable, should have a band guard with side flanges extending inward beyond the root of the teeth. If there is a spoke hazard, the gear should be completely enclosed, or filled in between the spokes.

Horizontal belts, ropes or chains which come within 7 ft. of the floor or working level, or which must be approached while in motion, should be guarded on the sides and bottom. Overhead belts 6 in. or more in width and running 30 ft. or more per second, more than 7 ft. above floor or working level, when located so that, should they break, they would endanger persons below, should be guarded underneath. All vertical and inclined belts (except belts one inch or less in width) should be guarded to a height of 6 ft. from floor or working level. If the highest part of belt is less than 6 ft. from the floor level, the guard may extend over the top of belt instead of being carried higher. The following requirements for guards are recommended:

Distance from Thing Guarded, In.	Height of Guard, Ft.	Maximum Size of Opening, In.
0 to 4	6	½ in.
4 to 15	6	2 in. square or 1 in. between slats.
15 to 20	3.5	Standard railing preferably filled in.

*Abstract of lecture delivered before the Schools for Safety Engineers conducted by the National Safety Council at St. Louis, Pittsburgh, Rochester, N. Y., and Cleveland.

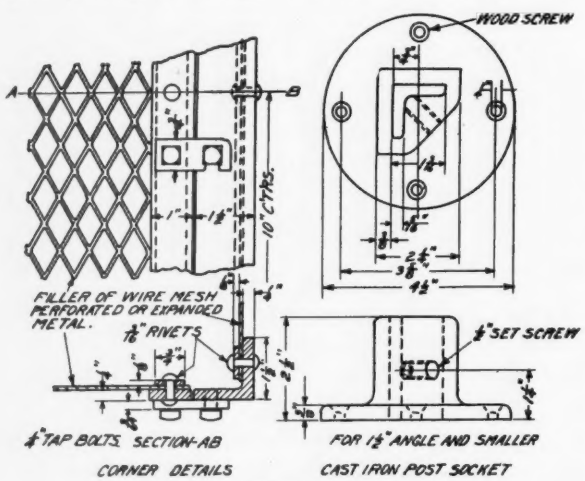
The metal frame of a guard 6 ft. in height, or which has a side dimension of over 3 ft., should be at least equal in strength and stiffness to a 1¼ by 1¼ by ⅛-in. angle iron. The filler may be attached to the angle frame by means of ¾ by ⅛-in. flat iron, fastened to the angle by 3/16-in. bolts or rivets (rivets preferred), placed not more than 10 in. between centers. Some companies spot weld the filler to the angle frame and use no flat iron.

If no overall dimension of the guard exceeds three feet, or if the guard may be suitably braced to provide a rigid construction, the frame should be equal to ¾ by ¾ by ⅛-in. angle iron.

Shafting, couplings, clutches, collars, and set screws should have all dangerous projections removed, where practicable, and should be guarded if within 7 ft. of the floor or working level.

Machine Guarding

Every circular saw should be equipped with a hood guard, of light but substantial construction, counterbalanced or easily adjustable so it will rise when stock is introduced. It should permit a clear view of the saw at point of operation. It should be rigidly supported in such manner that it can be swung out of the way when necessary but cannot be readily removed from the machine. A saw guard which works hard, or requires frequent adjustment, is of no value because the men will not use it.



DETAILS OF STANDARD BELT GUARD

Every rip saw should be equipped with a splitter.

Every hand fed jointer should be equipped with a cylindrical cutter head, and a guard should be provided to cover the head. The best type of jointer guard is that which covers the head at all times; the guard, or a portion of it, moving when the stock is fed in. The guard should be provided with a counterweight or spring so it will be returned to its original position when not in use. For feeding short pieces, use a push-block.

Every shaper should be equipped with a guard for the cutting head and, when the work permits, with a form for guiding the work. A suction hood connected with an exhaust fan should be provided for each shaper, as well as for other woodworking machines. This hood will often serve as a guard for the knives.

Much care and study is necessary in the guarding of power presses. Attention should be given to the correct design and construction of the dies with a view to accident prevention; cutting away portions of the die block will often provide a safe space for the operator's hand in feeding. An automatic feed should be provided on all power presses, where possible. This will greatly increase the output as well as prevent accidents. If no automatic feeding device can be installed, nearly all blanking operations can be effectively safeguarded by a wire mesh or perforated metal enclosure around the plunger, with enough space below to admit the stock but not the operator's fingers. The stripper can often be made thick enough to serve as a guard, the plunger not rising above the stripper. For many forming operations this is impracticable, and it is then necessary to provide some device which will insure that the workman's hand will be removed from the danger zone when a stroke occurs.

Other Safeguards

A railing used to guard machinery or floor openings, or on platforms or stairways, should be at least 3½ ft. high and should have an intermediate rail midway between top rail and floor. If used around a flywheel pit, floor opening, platform, etc., it should be equipped with a toe-board. Railings of rolled shapes (angle iron) are recommended for wear; in engine rooms, however, pipe railings are more commonly used because of their appearance. Railings should be provided on all sides of open stairways, platforms, etc.; on at least one side of enclosed stairways not more than 3½ ft. wide; on both sides of stairways over 3½ ft. wide; on both sides and in center of stairways over 7 ft. wide.

Ladders are a good example of plant equipment, other than machinery, which requires to be safeguarded. The ladder itself must be strong enough to carry as many men as may ever go on it at one time, with a factor of safety of at least two. Homemade ladders require especial attention because they are likely to be poorly put together or to contain defective material. Portable ladders should be equipped with anti-slip bases of a type suited to the floor on which the ladder is used; for rough wood floors, metal points or lead-coated bases; for concrete floors, lead or carborundum. Before purchasing any kind of anti-slip base or shoe, test it out on the floor where it is to be used and make sure that it will not slip. For some kinds of floors, such as iron or wet concrete, it is almost impossible to find a ladder shoe which will not sometimes slip. In such cases, the only safe practice is to station an attendant at the foot of the ladder, or to lash the ladder at top or bottom or both.

Stationary ladders should have proper clearance on all sides—8 to 12 in. in the back, 24 to 36 in. in front, 15 in. on each side of the center line of the ladder. For vertical ladders, especially if of considerable height, an enclosure or back-rest is desirable.

Still the government is piling up a huge monthly deficit in its operation of the railroads. For May, according to figures just made public, about $39,000,000 will have to be raised by taxation of the people of the country to make good the rental obligation to the owners of the railroads.

Save first; spend afterwards—buy W. S. S.

Draft and Chimney Proportions

FACTORS INFLUENCING THE DRAFT AVAILABLE, AND APPLICATION OF CHIMNEY DIMENSION FORMULAS

TO CAUSE the necessary weight of air to flow through the fuel bed and force the products of combustion through the gas passages of the boiler and setting, a pressure difference between the ashpit and uptake, commonly called draft, is necessary.

Strength of draft required depends upon the grade of fuel, the rate of combustion, and upon the form and length of the various passages. The resistance to be overcome is commonly considered in three classes: that between the ashpit and the furnace, between the furnace and the breeching entrance, and the breeching and stack.

DRAFT FOR DIFFERENT FUELS

WITH free burning bituminous coals a comparatively light draft is best, the required amount increasing as the percentage of volatile matter diminishes and the fixed carbon increases. Small sizes of anthracite require the greatest draft. Other factors, such as thickness of fires, percentage of ash and air spans in the grates, will, of course, bear directly on the question of the draft best suited for a given rate of combustion. Figure 1 shows the approximate intensity of draft required between furnace and ash pit to burn various fuels at different rates of combustion.

In the furnace or through the fuel bed, the draft loss varies between wide limits depending largely upon the size of the coal on the grate and thickness of fuel bed. Should the draft be too great, the coal may be rapidly consumed on certain portions of the grate, leaving the fire then in spots with the resulting losses due to an excessive amount of air.

DRAFT LOSS IN BOILER

THROUGH the boiler proper, the loss in draft will depend upon its type, size and arrangement of tubes and baffles, and will increase with the per cent of rating at which it is operated.

At normal ratings, this loss is approximately 0.25 to 0.3 in. of water for horizontal return tubular boilers, 0.2 to 0.35 in. for B. & W., 0.49 for the Heine, 0.51 for Stirling, and 0.43 for vertical tubular boilers of the Wickes type. These figures assume the burning of bituminous coal at the rate of 25 to 30 lb. per sq. ft. per hr., and should be increased about 55 per cent if the boiler is operated at 150 per cent of its rating and by 75 per cent when run at 200 per cent of its rated capacity.

For estimating the draft loss in flues or breeching the following values are commonly employed:

Horizontal flues, square or rectangular, allow 0.13 to 0.15 in. water per 100 ft. length. These figures should be increased 50 per cent for brick lined flues. Loss of draft, easy right angle bends, 0.05 in. water, through economizers not less than 0.3 in.; and for a superheater, approximately 0.15 in.

It is customary to make the flue or breeching area approximately 10 to 15 per cent greater than the area at the top of the stack to which it connects, the cross-section being reduced in proportion to the volume of gas to be handled as the breeching approaches the boilers in succession. One boiler manufacturer recommends a flue area of 35 sq. ft. per 1000 b.hp.

Methods are offered occasionally making the area of gas passages bear a certain ratio to the area of the grate surface. For horizontal tubular boilers a common rule is to make the area over the bridge 1/7, the flue area 1/8, and the chimney area 1/9 of the grate surface.

This rule, Kent says, may be considered approximately practical for average conditions with anthracite coal and moderate draft, and a combustion rate of about 12 lb. per sq. ft. per hr. and a ratio of heating to grate surface of 30 to 1. It is apparent, however, that if the draft were increased to double the rate of combustion and cut the grate surface to a 60 to 1 ratio, the areas of the gas passages would not be reduced proportionately.

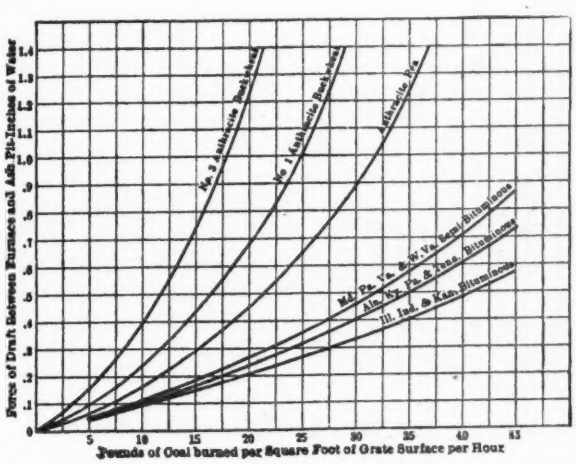

Force of Draft Between Furnace and Ash Pit-Inches of Water
No. 3 Anthracite Buckwheat
No. 1 Anthracite Buckwheat
Anthracite Pea
Md. Pa. Va. & W. Va. Semi-Bituminous
Ala., W. Va. & Tenn. Bituminous
Ill. Ind. & Kan. Bituminous
Pounds of Coal burned per Square Foot of Grate Surface per Hour

FIG. 1. DRAFT REQUIRED FOR VARIOUS COMBUSTION RATES AND DIFFERENT FUELS

In common practice, area of the air passages through grate bars is made equal to 30 to 50 per cent of the area of the grate; the larger the air passage area, the less is the possibility of stoppage of the air supply by clinker.

SIZE OF CHIMNEY

"CHIMNEY" and "stack" are terms commonly employed synonymously. In builder's practice "chimney" is the term commonly applied to masonry or concrete structures, the term "stack" being used for steel structures.

In proportioning chimneys the height is usually first determined, or assumed with proper consideration for the height of surrounding buildings, the length of the flues, the character of the fuel to be employed and other pertinent conditions. Heights exceeding 200 ft. are extremely expensive to erect, and except in special instances the cost is seldom justified. In recent practice

the use of two or more smaller chimneys has become rather common.

Gebhardt gives the following formula for the relation between the theoretical draft and the effective height based upon the difference in weights of a column of heated gas inside the stack and a column of outside air:

$$D = H\left[\frac{7.64}{T\,a} - \frac{7.95}{T\,c}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

in which D = maximum theoretical static draft, inches of water, H = effective height of chimney, T a = absolute temperature of the outside air, deg. F., T c = absolute temperature of the chimney gas, deg. F. Based upon this formula and assuming an outside air temperature of 60 deg. F., the graph of Fig. 2 gives the theoretical draft power for various heights and stack temperatures.

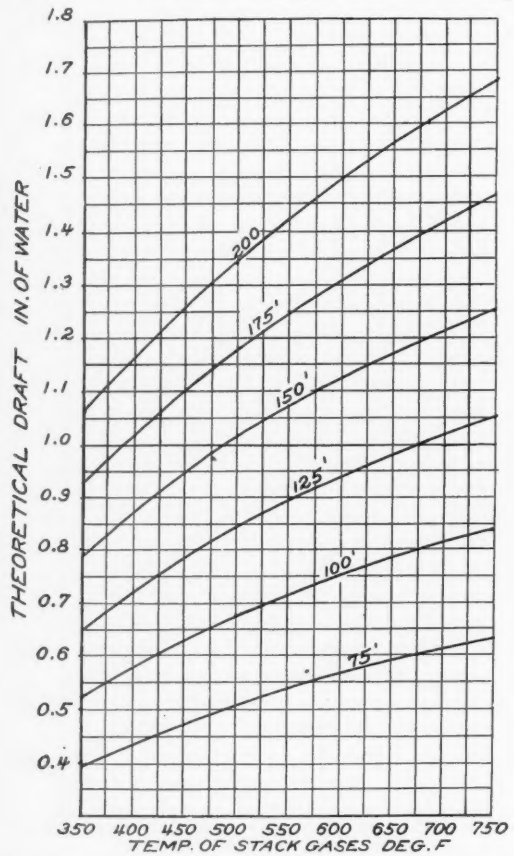


FIG. 2. THEORETICAL DRAFT POWER OF CHIMNEYS

To determine the chimney dimensions for a given boiler horsepower, Kent's formula is widely used:

$$E = \frac{0.3\ hp.}{\sqrt{H}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

in which E = effective area, hp = rated boiler hp., and H = height.

This formula was developed on the assumption: 1. That the draft power of the chimney varies as the effective area and the square root of the height. 2. That friction head of the chimney is considered as equivalent to a dimension of the chimney area, or to a lining of the chimney by a layer of inert gas 2 in. thick.

The formula is first hp. = C E $\sqrt{H}$, in which C is a constant. From numerous examples in practice, Kent found C is 3.33 when 5 lb. of coal is burned per hp.-hr. Then hp. = 3.33 E $\sqrt{H}$ = 3.33 (A — 0.6 $\sqrt{A}$) $\sqrt{H}$, or $E = \frac{0.3\ hp.}{\sqrt{H}}$.

Based upon this formula and assuming the coal consumption to be 5 lb. per hp.-hr., the size of chimneys for steam boilers is given in the table. This liberal fuel consumption allowance is made to cover the use of poor coal and for boilers being driven beyond their rated capacity. For any other rate of combustion multiply the tabular value by the ratio of 5 to the maximum rate expected:

Gas velocities commonly allowed in chimneys vary from 17 ft. per sec. for a 24-in. diameter stack to 31 ft. per sec. for a 72-in. diameter or above.

One of the formulas assumed to give the most economical diameter for an unlined steel chimney or stack which is employed by many engineers is, d = 4.68 $\sqrt{(hp.)^5}$, in which d is the diameter in inches and hp. is the rated capacity of the boilers served.

SIZE OF CHIMNEYS FOR STEAM BOILERS

Diam. Inches	Area (A) Sq. Ft.	Effective Area $\frac{A}{1+\frac{A}{2}}$ Sq. Ft.	Height of Chimney 50 Ft.	60 Ft.	70 Ft.	80 Ft.	90 Ft.	100 Ft.	110 Ft.	125 Ft.	150 Ft.	175 Ft.	200 Ft.	225 Ft.	250 Ft.	300 Ft.	Equivalent Sq. Chimney Side of Sq. $\sqrt{E}+4$ Inches
			Commercial Horsepower of Boiler*														
18	1.77	0.97	23	25	27	29	....	....	....	....	....	....	....	....	....	....	14
21	2.41	1.47	35	38	41	44	....	....	....	....	....	....	....	....	....	....	19
24	3.14	2.08	49	54	58	62	66	....	....	....	....	....	....	....	....	....	22
27	3.98	2.78	65	72	78	83	88	....	....	....	....	....	....	....	....	....	24
30	4.91	3.56	84	92	100	107	113	119	....	....	....	....	....	....	....	....	27
33	5.94	4.48	....	115	125	133	141	149	156	....	....	....	....	....	....	....	30
36	7.07	5.47	....	141	153	163	173	182	191	204	....	....	....	....	....	....	32
39	8.30	6.57	....	....	183	196	208	219	229	245	....	....	....	....	....	....	35
42	9.62	7.78	....	....	216	231	245	258	271	289	316	....	....	....	....	....	38
45	12.57	10.44	....	....	....	311	330	348	365	389	425	....	....	....	....	....	45
54	15.90	13.51	....	....	....	....	427	449	472	503	551	595	....	....	....	....	48
60	19.64	16.98	....	....	....	....	536	565	593	632	692	748	....	....	....	....	54
66	23.76	20.83	....	....	....	....	....	684	722	776	849	918	981	....	....	....	59
72	28.27	25.06	....	....	....	....	....	835	876	934	1,023	1,106	1,181	1,253	....	....	64
78	33.18	29.75	....	....	....	....	....	....	1,038	1,107	1,212	1,310	1,400	1,485	1,566	....	70
84	38.48	34.76	....	....	....	....	....	....	1,214	1,294	1,418	1,531	1,637	1,734	1,830	2,005	75
90	44.18	40.19	....	....	....	....	....	....	....	1,496	1,639	1,770	1,893	2,008	2,116	2,316	80
96	50.27	46.01	....	....	....	....	....	....	....	1,712	1,876	2,027	2,167	2,298	2,423	2,654	86
102	56.75	52.23	....	....	....	....	....	....	....	1,944	2,130	2,300	2,459	2,608	2,750	3,012	91
108	63.62	58.83	....	....	....	....	....	....	....	2,190	2,399	2,592	2,771	2,939	3,098	3,393	96
114	70.88	65.83	....	....	....	....	....	....	....	....	2,685	2,900	3,100	3,288	3,468	3,797	101
120	78.54	73.22	....	....	....	....	....	....	....	....	2,986	3,226	3,448	3,657	3,855	4,223	107
132	95.03	89.18	....	....	....	....	....	....	....	....	3,637	3,929	4,200	4,455	4,696	5,144	117
144	113.10	106.72	....	....	....	....	....	....	....	....	4,352	4,701	5,026	5,331	5,618	6,155	128

*Based on a consumption of 5 lb. of fuel per boiler horsepower. For any other rate multiply the tabular figure by the ratio of 5 to the maximum expected coal consumption per horsepower per hour.

To apply the rules and principles outlined, it will be well to work out a problem in chimney proportions for an assumed boiler installation.

Illustrative Example

Assume a boiler installation as described below, to determine the height and diameter of a suitable brick chimney. Four 200-hp. B. & W. boilers are to be served.

The flue 100 ft. in length has two right-angle turns upon entering the breeching and stack. Illinois bituminous coal is burned at the rate of 30 lb. per sq. ft. of grate surface per hr., the mean temperature of the flue gases is 550 deg. F., and that of the outside air 60 deg. F.

Draft loss through grate (from curve in Fig. 1.)..0.33 in.
Loss in boiler.....0.30 in.
Loss in flue (100 ft. at 0.10 per 100).....0.10 in.
Loss in turns (2 × 0.05).....0.10 in.

Total required at breeching entrance to stack..0.83 in.
Assuming that the effective draft is about 80 per cent

of the theoretical maximum static draft, $D = \frac{0.83}{0.80} =$ 1 in. water approximately.

From equation (1) $1 = H\left[\frac{7.64}{520} - \frac{7.95}{1010}\right]$

Ta = 60 deg. F. + 460. Tc = 550 deg. F. + 460.

$$H = \frac{1}{\frac{7.64}{520} - \frac{7.95}{1010}} = \frac{1}{0.0069} = 145 \text{ ft.}$$

To determine the area necessary, we will use the formula (2), which gives:

$$E = \frac{0.3 \times 800}{\sqrt{145}} = \frac{240}{12} = 20 \text{ sq. ft.}$$

From the table we find this area is given by a round stack 66 in. in diameter or a square chimney with a 59-in. side.

Experiences at the Glendale Power Station

A Letter from John Blake to Albert Wallace and the Reply. By G. H. Kimball

DEAR WALLACE:

After working with you so long, it hardly seems possible that you are not to be in charge here any more. We have now had some weeks of Graham as chief, and I am afraid that things are going to happen soon. Of course there has been water enough so far, but he thought that he would grind some of the fuel valves on the oil engine the other day, and you remember how hard those atomizers go in when the packing is rusted on them. Well, he got one out after a while, and after grinding the fuel valve, he started the atomizer, and as it went hard, he drove it in with a block of wood and a hammer. Won't there be a nice time when they are stuck so hard as that? It would seem to me that with all of that fuel oil working through, there would be no corrosion; let me know when you write.

Graham set out to fix the clutch on No. 2 railway machine this week, and he managed to get the wood shoes riveted in place; he came in after the cars stopped at night to take the bushings out of the pulley, and there was some strong language before he finished. He and some of the linemen worked until daylight, and they were no nearer getting them out than before, and as it was time for the cars to start, he had to give it up for that night. He asked me if I did not think that the pulley would run all right as it was, when the clutch was fixed up, and I told him that you always fixed the bushings. He is going to let it go for a while; so if you will give me a few points, I will see if I can get them out myself.

One thing that seems plain is that you were lucky to have hired somebody else last fall when you needed a man instead of Graham, for I think that he and work had a falling out some time ago. His idea seems to be to sit around most of the time, and you know what that leads to in a plant like this. How it is going to run when the water gets low is beyond me.

You know that the triplex pump has to be seen to once in a while, so he thought he would pack it the other day, and I think that he got the packing in all right and then he started it up and tried to prime it, and he had closed the valve on the discharge line, so that when the water came there was no chance for it to run anywhere, so the pressure blew off the air chamber. He kicked considerably about the relief valve not being next to the pump, which is where it should be; but, at the same time, I could not help thinking how we had run the pump for 5 yr. and not had a difficulty. He ordered another air chamber through the office which will be here in a few days.

I will have to stop now as I must go to work; let me hear from you as soon as possible.

Your friend,

John Blake.

My Dear John:

Your letter came yesterday, and as you asked for some information, I decided to write at once. This is sure some plant, and there is plenty to do for one while. You see, they have two factories here, and in one, which is called the main factory, they have a Green engine of 150 hp. which drives the main line of shafting by a belt, and there is a 200-kw. alternator connected to the shaft, and at the other end two vertical water wheels are geared to it. They can develop about 100 hp. in all, which is not much. Then outside of this factory they planned to build a generating station with oil engines and boilers for heating.

They first erected a temporary building to house a three-cylinder engine, and this was later increased by adding three more cylinders and putting a larger generator on it. After some time the oil unit did not seem to work as well as they thought that it would, and from the appearance of the trees that are around here I think that it must have smoked some. I also hear rumors, although the officials won't say anything, that the service was rather unreliable. At any rate, I heard today that they had decided to have the power plant as far removed from the buildings as possible, so that the black smoke will not ruin the glass. The inside of the wooden building looks like some old roundhouse where they keep locomotives. We did not seem to have much smoke up at Glendale, so there must be something wrong here. They are dismantling this unit, and it is to be moved about 2000 ft. distant, where there is a new one working, and they have an exhaust pipe on that running out into the trees.

Before I go any farther, I must answer your questions. About the atomizer that the fuel valve runs through, you know that this is made of brass and of quite delicate construction, and its purpose is to allow the fuel oil and air to mix, and when the needle valve is opened the fuel is sprayed into the cylinder and burned by the heat of the compressed air inside. After the atomizer is put in there is a small bronze packing ring, and once I had a very hard time getting this out. Finally I had to take a hook-shaped bolt and put a washer on the outside of the hole and draw it out, but it was pretty well roughed up when it came out. Its purpose is only to keep the packing from being forced into the atomizer and plugging up the holes. The oil contains acids to some extent, and this causes the packing to rust to the sides of the stuffing box. The only way to prevent this

trouble is to change the packing frequently and soak it in cylinder oil when it is outside. In a case like the one you mention the stuffing box should be thoroughly cleaned out, so that the atomizer will slip in easily by hand.

In regard to repairing the bushings in the pulley, as you know they are babbited and are in four parts, and after the pulley has been stopped for many times this babbit becomes worn, so that the pulley begins to ride on the clutch more than it should, then it begins to run out of true, and this will wear the shoes out also. Thus I found that it is always wise to renew the babbit in the bushing. To get them out, loosen the hub bolts and drive wedges in between the halves of the hub, and this should loosen the bushings enough to allow them to slip out. When replacing them be sure to put the set screws back in the right place, so that the oil holes will coincide. When replacing the clutch, tighten the hub bolts as much as possible first, leaving those on the arms until the last. After starting up when the pulley is stopped set the brake under the lower side, so that it will just take up the tension of the belt and not force the pulley hard against the shaft on that side, for this would cause the bushings to heat and wear very fast. In tightening the clutch I found that the best practice was to loosen up all of the adjusting screws and tighten each jaw on the same spot on the ring, so that all of the jaws run equally distant from the center of the shaft.

I am surprised that Graham is not showing up any better, for he has been in some big plants and should have learned to do good work.

We have a superintendent of power here who has never had anything to do with oil engines, and he is rather skeptical about their success. He means well, but it takes a long time to explain matters, and he can ask a good many questions in a short space of time. He has considerable work ahead of him, for besides the plants which I have told you about, there is a steam plant down here with a 600-hp. Corliss engine, and there are two more water wheels, each with its own generator, so that this makes four plants, all of which are to be combined except the water-power plants, which will have to stay where they are, but there are times when they don't amount to much.

I have not gone down to the oil plant that is running yet, as Mr. Curly, the superintendent, says that there is a man there by the name of Gooch, who can't get along with anybody, so the weather looks squally.

Yours truly until next time,

ALBERT WALLACE.

Ideas Under a Bushel

BY W. F. SCHAPHORST

FOR some reason or other, the natural tendency seems to be "keep mum about trade kinks." When a worker, foreman, or anyone else discovers an easier way to do something, he hastily looks around to see whether or not anybody saw him do it in the newer way. He thinks to himself, "This kink is too valuable to reveal to others. I'll keep it myself, and it may help me sometime." He, therefore, keeps it to himself. He does the work the "old" way because the "new" way is his secret, and he fears somebody will steal his ideas from him. The longer he keeps it, the more valuable it seems to him. He never lets go of it, and perhaps lives to see someone else discover the same trick. The "other fellow" tells about it in the technical or trade papers and forges rapidly to the front.

Ideas are valuable, true enough; but they are of no value whatsoever if they are not used. If an idea is good and is patentable, and seems to be worth patenting, the thing to do is to take out a patent.

Many ideas that are good are not patentable. For example, in many plants time and energy are lost blowing dust and lint out of machines with hand fans. That is the way it always has been done, and for that reason the foreman thinks that is the way it must be done. A girl who had to do the work in one plant suggested one hot day that the foreman furnish her with an electric fan for doing the same work. He "tumbled" and furnished the fan. It worked nicely, did the work better, more quickly, and did not cause the girl to overexert herself. Many little improvements of this simple nature are possible in and around the plant.

A friend of mine explained it to me in this way not long ago. He said, "Let us trade dimes." You give me a dime for one of my dimes. We traded. Then he said, "We haven't progressed a bit. You are no richer than you were before." I agreed with him. "Now," he said, "Let's trade ideas. You tell me how to rearrange my belting system to save power and I'll tell you how money can be saved on lubricants." I agreed, and we traded ideas. He then showed me that we were both richer in ideas. The progressive man isn't afraid to tell what he knows or ask questions about what he doesn't know. He doesn't keep his light under a bushel.

THE U. S. SHIPPING BOARD Emergency Fleet Corporation has arranged for the sale of its surplus and salvage property, including supplies, material and equipment, at such times and in such manner as may be deemed to be to the best interests of the corporation and the nation.

Complete manufacturing plants, entire shipyards, drydocks, ships, complete or half built, and any article down to scrap metal are among the items to be disposed of by public sale. These sales will afford an unusual opportunity to the industries which stand in need of material, equipment and supplies of the kind employed by the Emergency Fleet Corporation in its numerous branches of activity, but there will be no "unloading" upon either the general or local markets.

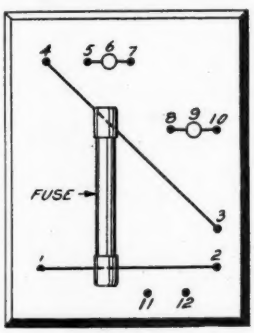
To sell to the market, and not to break the market, is the government policy in disposal sales to be held by all departments and branches. This policy will be strictly adhered to by the Fleet Corporation.

Upon the sales list are marine railways, housing and transportation projects, numerous allotments of machinery, equipment and supplies, including woodworking machinery, machine tools and fixtures, electrical machinery, boiler and forge shop equipment, marine equipment and accessories, air compressor equipment, contractors' equipment and supplies, bridge and gantry cranes, steel plates, shapes and bars, pumping machinery, scrap metals, lumber, deck equipment, galley equipment, hospital and commissary supplies and the like.

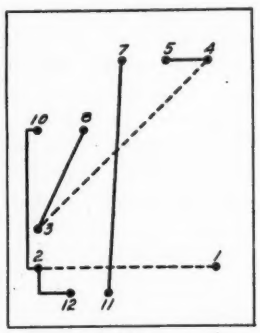
A Handy Fuse Tester

FOR THE BACK BOARD of this fuse tester I used two pieces of asbestos each 18 in. long, 10 in. wide and ¼ in. thick which were separated by two strips each 2 in. wide, 10 in. long and ¼ in. thick at top and bottom. All wiring is done on the front board, the back board being provided to protect the wiring and connection against injury.

In Fig. 1, showing the front side, 1 and 2 are binding posts which hold the lower testing bus in place; 3 and 4 are also binding posts which hold the upper bus in place. These busses are made of bare copper wire and the binding posts are stove bolts; 5 and 7 are binding posts of lamp receptacle 6, while 8 and 10 are binding posts for plug testing receptacle 9. The threads on



FRONT
FIG. 1



BACK
FIG. 2

FIG. 1. FRONT SIDE OF TESTER SHOWING METHOD OF APPLYING FUSE

FIG. 2. REAR OF FRONT BOARD ILLUSTRATING ELECTRICAL CONNECTIONS

brass collar into which the lamp screws into the socket are flattened out so that a plug fuse which is to be tested need not be screwed in to make connection, but merely pushed in until it makes contact when lamp 6 will light up if the fuse is O. K.

Figure 2 shows the wiring on the back of Fig. 1 with the testing bus represented by the dotted lines; 11 and 12 are the terminal binding posts for a 110-v. supply.

To use tester, close the main switch on tester or put plug in on lamp circuit and have a good lamp in receptacle 6. Then take fuse which is to be tested and put it on the part of the bus which it will fit properly as shown in Fig. 1 by letting one ferule of fuse rest on lower bus and the upper ferule of fuse on upper bus, and if this is O. K. the lamp circuit will be completed between 1-2 and 3-4 by means of the fuse and the lamp will light up. If, however, the fuse is not any good the lamp will remain dark because the test lamp circuit is open through the fuse.

Fuse plugs or lamps can be tested by placing them in receptacle 9 and if fuse plug is O. K., test lamp will light up. If a 110-v. lamp is put in receptacle 9 to be tested and the tester is on a 110-v. circuit, the test lamp and lamp to be tested (if O. K.) will not light up fully at half voltage as they are in series across the circuit. I have tested fuse from 11 to 12 in. by means of this device.

DEAN REYNOLDS.

Ignorance Versus the Indicator

EVEN in these days of modernized industry, one occasionally meets with an antiquated engineer whose prejudice or ignorance has prevented him from accepting the steam engine indicator as a necessary "evil." He argues thus: Rule of thumb methods have always proved sufficient to admit of his "getting along." An indicator may be perfectly satisfactory to those persons who actually feel the pressing need of one, but surely he does not. He is now too old to step from the well-beaten path of hard knocks which have given him his engineering education and start all over again endeavoring to absorb the mysteries of new-fangled contraptions to which "there ain't no sense anyhow." In short, the good old hit-or-miss methods are plenty good enough for him. He scarcely realizes that it is that very hit-or-miss manner in which he works that has made for his inefficiency and has helped make stationary engineering, in the main, one of the poorest paid of professions, as professions go.

Is it any wonder that, not so many years ago, mill owners looked upon their steam plants as a huge debit. They purchased the cheapest equipment possible to buy and placed in charge thereof an incompetent man who often was either unable, or did not care, to learn.

There are still a few of these men remaining in this up-to-date world and simply to prove that such a man is very far indeed behind the times and to show how set in their ways some of them can be, mainly from pure dislike of having an "outsider" show him up, even unwittingly, a little illustration is in order.

While traveling through a Southern State on business, having occasion to wait several hours for a very late train, I improved my time by looking up Mr. Blank, the owner of a small mill located in the outskirts of the town. Incidentally, Mr. Blank was an old schoolmate of mine and our conversation covered everything from boyhood escapades to my present employment. Learning that I claimed to be an engineer, he made it a point to remark:

"I've a little mystery that possibly you can solve for me. My engineer cannot locate the trouble, none of my business friends can offer any solution and I am positive that I cannot."

"What leads you to think that I may be able to find it?" I asked him. "I'm no expert trouble man."

"I know that, but you don't mind my asking, do you?"

"Not in the least," I made haste to reply, hoping I had not offended him with my seeming show of indifference. "Give me the facts and I'll see if I can make anything of the case."

His engine, one of the simple Corliss type, had developed a suspicious clicking in both the steam valves. Removal of the valves and stems had revealed absolutely nothing alarming. Somebody had suggested that perhaps the clicking was caused by improper lubrication of the valves. Several lubricants were experimented with but the noise still continued.

One queer feature of the mystery was that the clicking occurred only at intervals and for varying periods of time, sometimes for a few minutes, sometimes for an hour or more. It didn't seem to affect the performance of the engine in any way, but it was decidedly annoying and nobody knew to what it might eventually lead.

Always keen to fathom such mysteries, I asked to be shown the offender.

When we reached the engine, the clicking was doing its best to be heard, and upon putting my ear close to the lagging, I could plainly hear the peculiar noise above the din of the mill.

The old engineer in charge seemed to resent my questioning; but I finally managed to learn that no card had been taken from the engine since the erector had set the valves, more than 2 yr. before. The engineer admitted that he had adjusted the valves to suit himself after the erector had departed and claimed that they were now in a position which he knew to be correct. He stated that he had been an engineer for the past 45 yr., knew absolutely when an engine was taking her steam correctly and didn't need an indicator to tell him, either.

That was sufficient for me. I felt that there was nothing to be learned from this man and I turned to Mr. Blank.

"Have you any objection to my indicating this engine? I have my indicator with me."

"Why, no, go ahead," he answered, with half a smile; "but I don't think you will find anything wrong with the valves."

I soon had the indicator rigged to the engine and the first card I took solved the problem for me. I made a few measurements of the card with a scaled rule and sat down for 10 min. to watch the steam gage, which I found hung between 90 and 100 lb. At the end of that time, I once more turned to Mr. Blank.

"You wouldn't care to bet a new hat, would you, that I can remedy that clicking?"

"Why, man, I'd buy you two hats if there was any hope of your doing that. I find myself stopping at that engine a dozen times a day to find out whether that darned clicking has ceased or not. It's always *not*. That hat is yours if you can stop it."

The card taken from the engine had disclosed too high compression at both ends of the cylinder, nearly 95 lb., while the gage pressure was but 90. It was evident that when the gage pressure was below 95 lb., the excessive compression lifted the steam valves completely from their seats at each stroke and the incoming steam slammed them back again when the piston started moving, causing the muffled clicking. When the gage pressure was greater than 95 lb., no clicking could be heard.

I asked Mr. Blank if I might adjust the valves during the noon shutdown. He assented; and but one adjustment of each exhaust valve was necessary to stop the clicking forever.

It all goes to prove that without an indicator, no man can swear he is in the right.

Needless to say, Mr. Blank thanked me profusely and immediately steered me into the nearest haberdashery, where he parted with his dollars. He saw me aboard my train and in parting informed me that, at his earliest opportunity, he would order a reliable indicating outfit and make a study of its vast possibilities.

JOHN WALLACE.

A Sadly Neglected Indicator Feature

IN THE last few years the amount of progress which has been made in the way of refinements of various machines and methods is extremely wonderful. It is gratifying to note what progress recording instruments have made and the wonderful saving they have made possible. At this day and time, however, when we are looking forward and striving to put into operation every known practical working device, we have most sadly slept in the improvement of an instrument which could be called a cylinder recording gage or a cylinder indicator. The thought which predominates among the users of indicators is that they were constructed mostly for aid in setting the valves of an engine so as to acquire the most economical results, and then from the diagram to calculate the horsepower.

With our present day engine indicating, the requirements vary; in some plants an indicator diagram is taken every 6, 12 or 24 hr., and some once a week, and in others only when an engine commences to pound, bearings work hot, or belts of various transmission mechanisms give trouble. Take the plant for instance in which the engines are indicated once every 12 hr., and as a rule from an operating week of six days the average horsepower is estimated by taking a general average of the operating load, as a matter of fact it is somewhere in the neighborhood of a fair estimate. A modern clock dial automatically recording and indicating pressure and horsepower is an instrument most sadly needed in any modern steam plant in operation. We may take an indicator diagram at 8:15 a. m., and ascertain the correct horsepower generated by the engine for that one revolution only, but what goes on inside the cylinder between the times of taking cards no one knows. With a good controlling governor our speed remains the same, but the power necessary to keep it so is constantly changing to some extent. This is caused from various things such as climatic conditions, overdue friction from the lack of lubrication at intervals or the throwing off or on of machines.

An instrument of this nature would be of as much assistance to the engineer in not only making correct

calculations, but in assisting him to locate more quickly unforeseen irregularities than he is equipped to do now.

How easy it would be with an instrument having a self-recording dial indicating pressure and horsepower to observe the many variations in your running horsepower from a diagram of this nature during a day's run and then go around and check up the absolute causes? I will admit that in many manufacturing plants a variation in speed, and especially horsepower is not troublesome and little attention is given to it; in manufacturing plants, however, where every revolution counts and all machines are supposed to be constantly in operation with reasonable allowances made, it is a very important issue, and in course of time runs into a loss of thousands of dollars.

All modern railroad engines are equipped with an instrument somewhat similar to this which is placed in the cab of the locomotive which records the hours, minutes and seconds the engine is not only running, but when it is stopped. So if railroad engineers have progressed thus far with such an instrument, why do not the stationary engineers take the same step, and only carry it a little farther in advance? The improvement gained will be surprising. H. W. ROSE.

Explosion Doors for Economizers

SOME YEARS ago I chanced to go in a plant that had the appearance of having met an earthquake and having come out second best. It was situated in a well-popu-

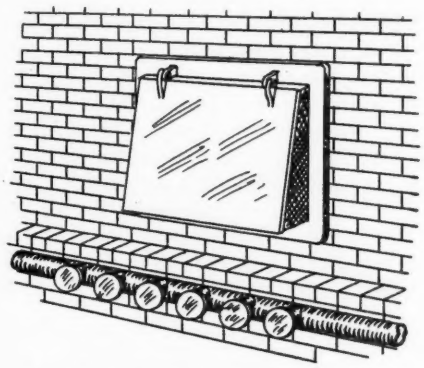


FIG. 1. EXPLOSION DOOR IN SETTING

lated district and furnished power to a large textile mill and consisted of several vertical fire tubular boilers and a modern (at that time) generating plant. The chief engineer, a man of sixty or thereabout, was apparently about in the last stages of apoplexy, and I made inquiry as to the cause.

I cannot preface the account that was given me of the chief's ailment as the assistant gave it to me, for the reason that it would not be published; but the true explanation was—economizer. The plant consisted, as I recollect it now, of seven Manning type vertical boilers, all connected to the same flue, which led the gases to a very high stack or through an economizer, as the operator willed.

This economizer was in a brick setting—that is to say, it had been in the brick setting; but early in the morning the bricks had left the setting through some strange freak of man or nature.

A loud report was heard and the attendant rushing toward the sound was met by a cloud of mortar dust so dense that he turned and rushed the opposite way.

An examination of the boilers proved them all in place, but the draft had gone and smoke was pouring out of the several open fire doors.

After the dust had settled, a second examination disclosed the fact that the economizer had shed its housing. It had never done that before and the question arose as to how the powder or nitroglycerin had got into it. The old chief was just as sure as could be that somebody had blown them up. He tried to think who had been dis-

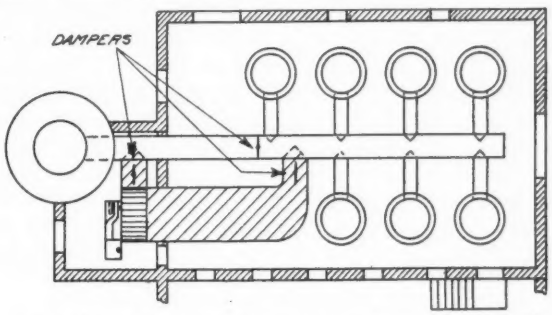


FIG. 2. LAYOUT OF PLANT SHOWING DAMPER LOCATION

charged and whether the guilty party could have gotten into the boiler room without being detected.

After some time the boss foreman said: "Do you suppose, chief, that a charge of gas could have got in there and exploded?"

"Young man, I've been in this plant 27 yr. and I was holding down the job you are now when that apparatus was put in—that's about 22 or 23 yr. ago—and she never blew up before."

Somebody suggested there was always a first time, but the old chief froze this outspoken thinker so quickly that he was a dummy for the rest of that session.

After leaving the plant, I came across a traveling acquaintance and I told him of the phenomenon.

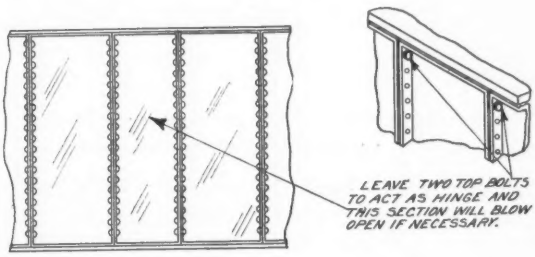


FIG. 3. MODERN PROVISION FOR EXPLOSION IN ECONOMIZER

He laughed and said: "I have thought a hundred times that some day the old man would meet with that kind of a surprise, but he is so kind of touchy that I have never told him of the sights of similar kinds I have seen."

Then I inquired what had caused the disturbance.

"Why, the gas exploded, that's all," he said. "You see, they probably punched the fires without starting the induced draft fan and the gas formed was so intense that it charged the economizer and when a spark came along the explosion took place.

"Had the old man installed a door in his brickwork it would have blown open and no damage to the setting would have resulted," and he illustrated by a sketch (Fig. 1).

I afterward found that the explosion door appeared to be somewhat of a necessity where vertical boilers were in use and can cite several cases of economizer explosions in plants of the type mentioned. I find that inspectors as a rule admit that more damage is done by gas explosions than by failure of tubes or headers.

The general rule today seems to be to build a metal housing for economizers with a nonconductor of heat filling, but even this housing should have a door to vent it in case of gas explosion. This can be done by taking the bolts from the angle iron frames of the sections, as per sketch, though I prefer a door made in the flue also.

By the way, the old chief mentioned in the beginning of this article had two doors placed in the new setting and also had doors of special design for the furnaces to let air in at all times by advice of consulting experts.

TOM THUMB.

Improvement in Valve Disc

IN SOME MAKES of pumps are installed a valve of the type shown in Fig. 1. These valves will wear out in a very short time, due to incorrect design. Figure 1 represents the old valve disc. The brass cover plate, E, Fig. 1, is affected the same way as the hard rubber disc, C, both wearing at the hole in the center. The conical compression spring, F, also wears out in a short time.

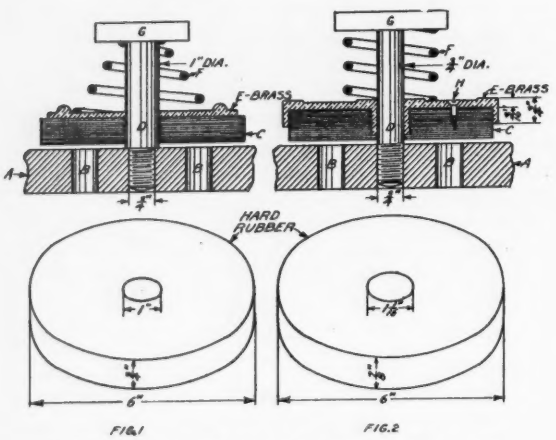


FIG. 1. COMMON STYLE OF PUMP VALVE DISC
FIG. 2. VALVE DISC OF IMPROVED DESIGN

In order to overcome the frequent exchanges of valves and repairs, I designed the valve shown in Fig. 2, which represents a cross-sectional view of the valve. A represents the valve chamber walls, and B, ports; C, the 7/8 by 6-in. hard rubber disc; D, valve stem or stud; E. the improved disc guide plate, and H, a number 12 wood screw for holding disc and plate together. In this design, the conical compression springs are discarded in favor of an open spiral compression spring, F.

In the old valve, the hard rubber disc has no guide except its own bare wall, and this is quickly destroyed on account of enormous pressure on the disc. A cover-plate, E, is so designed as to allow the hard rubber valve disc, C, to be placed solidly in the housing of plate, E, and at the same time secure a metal-to-metal guide for the valve proper.

Some months past I placed a tryout valve in one of our circulating pumps, also a new set of regular valves; those valve stems, plates. and conical springs have now been replaced by new ones, as they were worn out, and the improved valve shows practically no wear.

OTTO DORTHEN.

National Engineers' License Law

IN REGARD to this serious question, my views are that, if we do not rouse ourselves soon, it will be too late. Engineers' pay is the lowest, compared with the ability and training required, of any of the skilled trades in America today. Even unskilled labor is getting better wages, because of the effect of unionism.

Let us organize, amalgamate. Let us have one organization, the Amalgamated Society of Stationary Engineers, Oilers and Firemen of America. All should then be put under government control, with a central examining board, sitting once each year, and having branches throughout the country for doing the detail work. These boards should grant licenses good anywhere in the country.

The organization should form a graduate course for engineers. For instance, every man must serve 2 yr. as fireman and be given a certificate after being examined on firing. He should then serve 2 yr. as boiler room foreman, packing valves, cleaning boilers and attending to repairs and adjustments, this class of work not being done by firemen or engineers. One man might do the work for several plants, following up the insurance or government inspector, and seeing that all orders and suggestions are carried out. He would be paid by each plant according to the work done. At the end of 2 yr. he should be examined, and if proficient, given a license to operate boilers, in charge of a boiler room, and qualifying him as oiler or assistant engineer, in which capacity he should serve for another 2 yr., when he would have a final examination for engineers' license.

This would be a guarantee to the employer that he was getting a competent worker, and would justify the paying of high wages. It would also keep down the great overflow of so-called engineers from other trades.

Such a union would be a recognized power for advancement of quality and standing of the calling. It would become rich as it became powerful, and would be able to get what it desired in the way of proper working conditions and safety provisions for the workers and the public.

Now, boys, let's start a committee. Let one man in each plant send in the names and addresses of his associates, and the rest will be easy.

JOHN HANNAN.

Armature Chocks

SEVERAL years ago, at a power station, a 600-kw. spare armature was laid in specially built wood chocks. These chocks were made of oak for strength. After the armature was laid in, the shafts were smeared in vaseline. Quite recently, when the armature was lifted out,

the shafts were found to be seriously pitted (about 1/64 in. deep) all along the shafts where they had touched the chocks.

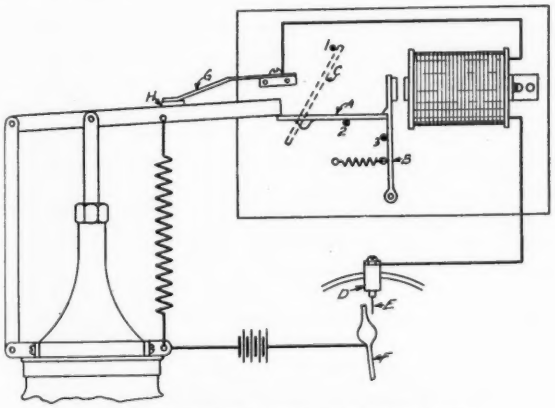
This was caused by the acid action of the oak.

MARK MEREDITH.

A Self-Closing Valve

OWING TO the fact that our plant is shut down early in the evening during the summer months, it became necessary to find some means of keeping hot water for the guests up till about midnight. To this end, we installed an auxiliary gas fired heater. The fire is controlled by a thermostat located in the regular heater tank and the arrangement works very well; but as there is no hot water needed after midnight, the manager asked if there was not some way of automatically shuting off the gas at that time. After studying the matter for some time, I worked out the device shown in the sketch and it is satisfactory in every way.

The valve is a rising stem gate valve, with the threads filed off the stem and a lever handle fitted on, which is kept in the closed position by the large spring. When



CONNECTIONS OF SELF CLOSING VALVE

the valve is open, the lever rests on the end of the small lever, A, which is kept in position by the trigger, B. The electric circuit is closed by a clock. This pulls the trigger back, releasing the lever, A, which then assumes position C and the valve is pulled shut by the large spring. As soon as the valve is closed, the circuit is broken at H. The small, flat spring, G, should be so adjusted that it will just break the circuit when the valve is completely closed. This is necessary, as the hour hand of the clock will take several minutes to pass the spring, E, and the batteries would not last very long were there not some other means of opening the circuit. Of course, just as soon as the valve is opened, the circuit will be completed at H and ready for the next closing operation.

The contact on the clock is a small fiber bushing, D, carrying a screw which has a very thin, flat brass or copper spring, E, soldered to the end. This is set into the front of the clock in such a way that the hour hand will just make contact with it at the time it is desired to close the valve.

This same arrangement might be used for the remote control of a valve, by using a push button instead of the clock to close the circuit. An electric bell should be placed in the circuit near the button. This will serve to indicate whether or not the valve has operated properly. If the valve closes, the bell will give one short ring no matter how long the button is held; but if it does not close, the bell will continue to ring as long as the button is depressed.

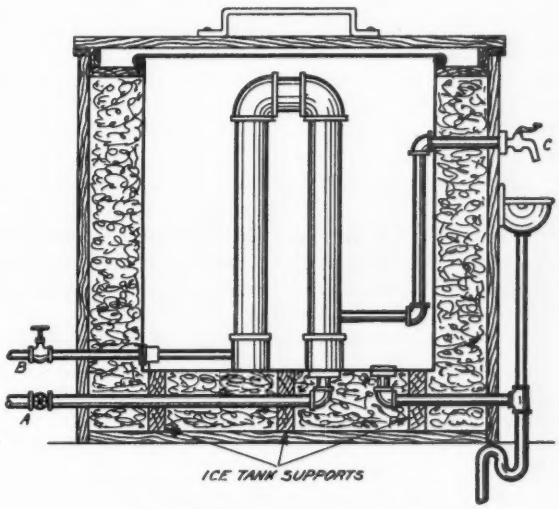
J. W. ESHNAUR.

Homemade Water Cooler

THE ARTICLE on cool drinking water systems by Charles L. Hubbard in the June 1 issue is very interesting and gives a lot of valuable information on the subject.

I once saw a homemade water cooler worked on the principle advocated in one part of Mr. Hubbard's article. It gave excellent satisfaction, one good point being that any handy man or mechanic could put the whole thing together with no outside help.

The inner or ice tank is square, made from galvanized sheet iron with soldered joints; the outer casing is made from 7/8-in. matched boards. The space between



EASILY MADE WATER COOLER

the two tanks was filled with mineral wool. All pipes passing through the iron tank, near or on the bottom, were made water-tight with locknuts and leather washers. The cooling coil was made with two pieces of 3-in. galvanized iron water pipe, capped on the bottom ends and connected with elbows at the top.

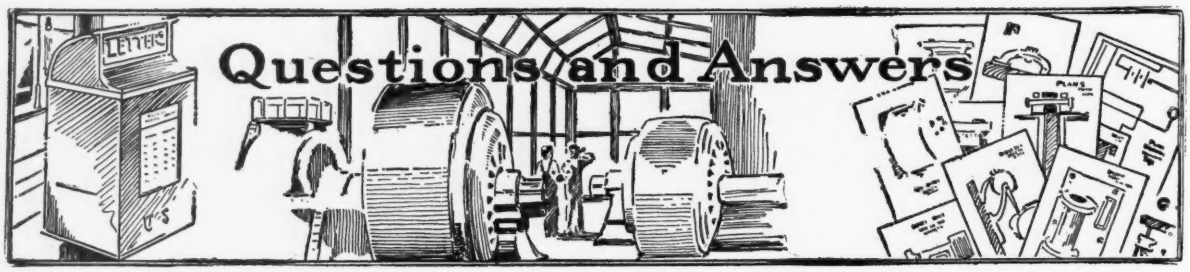
B is the city water supply pipe; A is a blowoff pipe connected to the bottom cap. Any sediment or dirt which collects can be blown out; the movement of the water in the big cooling pipes is so slow that any such sediment has a good chance to settle. A spring self-closing tap is at C. Of course a bubble fountain can be used instead of the spring tap, if desired.

Even if the waste pipe is not connected to a sewer pipe, it should be trapped to prevent the warm outside air flowing up into the ice chamber.

The sketch shows the idea of the cooler so clearly that no further description should be required.

The size of the tank can be such as the need of the case calls for.

JAMES E. NOBLE.



That Noisy Water Meter

ON PAGE 607 of the July 1 issue, T. G. complains of a noisy water meter, the cause of which he is unable to locate. To remedy his trouble I would suggest placing an air drum at the end of the water line in the building; this, I am sure, will do away with the noise.

C. BRAZIL.

I WOULD ADVISE T. G., whose communication relative to his noisy water meter appears on page 607 of the July 1 issue, to close all the valves leading from the meter and then note whether the noise continues. If so, the noise may be due to the leakage of some valve near the meter which may produce a humming sound and appear to originate at the meter. This may be particularly the case if pressures of from 75 to 100 lb. and more are being carried.

If upon investigation, this should not be found the cause of the trouble, I would suggest that T. G. open fully one or two valves and if the noise still continues, I feel safe in saying that it must be due to a defect in the meter. In such case, the only thing to do is to take out the old meter and install a new one.

An overloaded meter too small for the work it is called upon to do or one carrying an accumulation of rust or mud, perhaps clogging the inlet port, will frequently produce such noises.

H. W. ROSE.

Why the Voltage Drop?

FROM the information given by G. I., on page 564 of the June 15 issue, it appears as if his trouble may be due to low power factor, this resulting in too great a range for the regulator. To remedy this trouble I would suggest opening the main rheostat. L. CLARK.

Proper Lubrication of Oil Engine

TO T. C. P., WHO, as mentioned on page 519 of the June 1 issue, is having trouble with the ports of his engine filling with carbon, I would suggest that he put new cylinder rings in his engine. When both intake and exhaust ports fill up with carbon it is a sign that compression is leaking past the rings; perhaps the cylinder and piston are also scored, and in this case new rings will help, but not remedy, the trouble.

Put in new rings, never a whole new set at one time, and use a good grade of heavy gas engine oil, about 6 to 7 quarts to a 24-hr. run, and if the cylinder is not too badly scored there will be no trouble for some time.

Heavy Matchless Gas Engine Oil, put out by the Pure Oil Co., is very good, as is also the Diesel oil, put out by the Standard Oil Co.

Some time ago I installed a set of rings made to order and manufactured by the Evertight Piston Co., and find I am using considerably less fuel oil and about half the cylinder oil, and am not troubled with carbon gathering at any of the ports. G. D. ROTH.

Leaky Boiler Tubes

THE TROUBLE of T. H., as outlined on page 607 of the July 1 issue, is undoubtedly caused by scale on the flue sheet. I have worked on railroads before and since the introduction of soda ash and treated water and therefore know that previous to that time a yard engine was considered as doing well to run 12 hr. without some of the flues leaking. It was a case of calking and rolling all of the time, with a new set of flues once each year.

Since then, however, I have seen flues that would be so loose as to rattle with a cold boiler, although as soon as heat was applied they would expand and fit tightly.

In using soda ash a boiler must be blown down frequently or it will foam badly. This may, however, be prevented by placing a small valve or cock in the leg of the boiler and allowing a slight leak to occur. Putting an arch in the firebox will also keep the cold air from striking the flues and assist combustion.

To prevent the peculiar action of his well and feed pump, I would suggest that T. H. shut off the pump while the boiler is priming and note where the water goes. Very likely the piping is arranged so that the pump drains the steam header. The water should be carried lov in the glass, say, 1 in., and the blast turned on, and I am sure the boiler will generate sufficient steam.

W. G. WALTERS.

REPLYING to the letter of T. H., published on page 607 of the July 1 issue, a slightly overloaded boiler, if in good condition, is not dangerous; but one carrying an excessive overload is unsafe to operate.

I presume T. H. is carrying no boiler insurance, for insurance companies, as a rule, do not take such chances. The trouble referred to can be partly or in whole eliminated by expanding all of the tubes in such a manner as to prevent the existence of any and all slack and then well beading the ends—that is, rolling them back tight against the crown sheets. A 4-in. tube should not extend more than 3-16 in. beyond the crown sheet.

Recently welding has been employed. This process has proven quite successful and has entirely eliminated the leakage of tubes.

I would maintain a temperature of about 100 deg. F. in the boiler room and in that way permit the rush of cold air into the furnace with each opening of the

fire doors. I would especially strive to maintain this temperature during the period of clearing fires, as it is at this time that most of the damage is done to the tubes.

As a further aid to improve operating conditions, I might suggest that T. H. cover the top of his boiler with 75 per cent magnesia and give the side walls a good coat of insulating boiler plaster or paint.

If the steam chest connection of T. H.'s engine will take a 3-in. pipe, at least that size should be used all the way to the boiler. I would further provide a separator and a trap placed on the steam line within at least 4 to 6 ft. of the throttle valve or a U bend placed in the steam line as near the throttle as convenient, having, however, a small bleeder in the bottom of the U which could be controlled by a valve. Frequently the bleeders from such U bends are fitted with check valve and are piped back to the boiler so as to allow the return of the surplus accumulation of water in the U.

H. W. ROSE.

Brick vs. Steel-Cased Boiler Setting

FOR THE BENEFIT of H. W. J., whose communication appears on page 607 of the July 1 issue, I would state that an asbestos-lined steel casing is much more efficient than an ordinary brick setting. C. BRAZIL.

IN COMPLIANCE with the request of H. W. J. appearing on page 607 of the July 1 issue, I desire to quote an authority on the subject of boilers. This engineer states that where steel casing is employed "radiation losses from the surfaces of brick boiler settings combined with the losses due to air leakage have been eliminated, such elimination varying from 2 to 10 per cent depending upon the amount of radiation surface and condition of the settings." H. W. ROSE.

"Timing" Gasoline Engines

I WAS CALLED UPON to "time" two automobile engines which somebody took apart, and could not replace the timing arrangement so as to get the engines running again. I should be glad if you could outline the process followed in timing automobile engines. V. L. M.

A. Every automobile engine is timed somewhat differently, and the method of timing is somewhat different, so that all we can give you is a general idea of how this is done.

Usually on the flywheel there are marks showing the position at which the exhaust valves for the different cylinders should open and close, and also for the opening and closing of inlet valves. In the four-cylinder engine, exhaust valves one and four open and close together, also exhaust valves two and three; and likewise the inlet valves.

For the valves, the timing varies between the following limits: The inlet valve opens from 8 deg. to 13 deg. after the crank passes the top center, and closes from bottom center to 22 deg. past bottom center. With the exhaust valve, it usually opens at from 30 to 45 deg. ahead of the bottom center, and closes at from 5 deg. to 12 deg. past the top center.

To determine whether timing is right for the exhaust valves, for cylinders one and two for instance, the flywheel is turned until the mark corresponding to exhaust opening is opposite the trammel point, or mark, on the engine frame. The valves should then just be opening for exhaust. The flywheel is then turned in the direction of its natural motion, until the exhaust closure mark is reached, and it is noted whether these valves are just closing.

In like manner the action of the valves is tested out for all points on each cylinder, both for inlet and exhaust valves.

Of course, the time of opening and closing is determined by the setting of the gears on the main shaft and the cam shaft; by the setting of the sprocket wheels if the cam shaft is driven by silent chain. The cams on the cam shaft are usually solid with it, and are not adjusted on the cam shaft. The clearance between cam push rods and valve stems should be such that there is about 0.005 to 0.008 of an inch, when the cam push rod is clear down and the valve is closed.

On most automobile engines, the ignition is variable, the range being between ignition just after the crank passes dead center, when the spark is retarded, to 45 deg. ahead of dead center for the most advanced position of the spark. This range of variation will differ with different engines, and as a matter of fact, the best point for setting ignition is a thing that usually has to be worked out by experiment, but it is somewhat within this range.

The usual order of firing for the four-cylinder engine is 1—3—4—2, and the distributor should be connected up so that the firing will occur in this order.

Most automobile manufacturers issue an instruction book, adapted to their particular machines, and it would be advisable for you to get from the manufacturer of your machine an instruction book for the particular model with which you are working.

Ratio of Piping to Cubic Capacity in Ice Storage Houses

OUR COMPANY is planning the erection of an ice storage house, but we are unable to find any set standard for the ratio of piping to cubic capacity of such buildings, and whether 2-in. pipe is preferable to 1¼-in. pipe. The building is to be 70 by 50 by 30 ft. high and 4 in. of pure cork on walls of 12-in. cork employed, breaking joints, and 12 in. of granulated cork on ceiling; on the floor 3-in. cork board is used. There will be no windows.

W. H. M.

A. You are quite right that there is no set standard for the ratio of piping to cubic capacity in ice storage houses. It depends very largely on the kind of insulation used in the walls of the houses.

Siebel gives, that one foot of 2-in. pipe should be used for every 14 to 20 cu. ft. of capacity, where direct expansion coils are used; and 30 to 50 per cent should be added to this for brine coil refrigeration.

Assuming that you have direct expansion pipe, and with the insulation that you have, I should say that one foot of 2-in. pipe to 18 cu. ft. capacity would be about right. This would give you, for your 70 by 50 by 30 building—which has 105,000 cu. ft.—about 5800 ft. of 2-in. pipe. If you use 1¼-in. pipe you would need 8350 linear feet.

For this amount of piping it is usually cheaper to install the 2-in., and you have sufficient length so that it can be distributed just as satisfactorily. The piping should, of course, be run overhead, and you will get better control by using at least 1000 ft. in the coil. Less than this makes it more difficult to get a setting of the expansion valve which would be satisfactory.

The building should be arranged with a good ventilator at the highest point in the roof, and ventilating holes in the gable ends, so as to insure a good circulation of air in the upper part of the building to carry away the moisture. Also, the floor should be arranged so that there will be good drainage, and no water standing, at any time, under the ice. It is well to set the foundation on 1½ to 2 ft. of cinders. The other construction that you have should be very satisfactory.

Testing Bearing Cooling Coils for Leakage

IS THERE any way of testing the cooling coils in a bearing for leakage without removing the bearing cap and raising the shaft?

I have two large Curtis turbines and have noticed water at the bottom of the oil reservoir. In fact, after a week's run, as much as a pailful may be drained off.

A. A. F.

A. There is a way of testing out the cooling coils in the bearing lining for leakage. This is done with the machine shut down and steam shut off; measure the water in the bottom of the oil tank or draw it all off, then turn on the bearing cooling water, leave it on as long as it is convenient to have the machine shut down —then measure the water if there is any in the tank. If there is water with the oil, this must come from the cooling coils; you can locate which bearing it is by disconnecting the piping and putting water on each bearing separately. It is sometimes found that the pipe letting the water to the bearing is not screwed home; if this is not the case, it is possible the leak is of a more serious nature—that is, due to cracked coils in the lining. This will necessitate, usually, complete rebabbiting of that particular lining.

R. B. SCAMMON.

Stack Questions and Answers

BY USING a stack 48 in. in diameter instead of one 36 in., would the temperature of the gases be materially changed?

How would the velocity of the gases be affected?

2. Will you give me a formula for computing the number of boiler horsepower a given stack is capable of caring for?

3. By increasing the diameter of a stack and wishing to carry the same stack temperature, could I decrease the height?

J. P. N.

ANSWERS

DUE TO the increased area of the stack exposed to the atmosphere, greater radiation would result, and, as a consequence, the stack temperature may be somewhat reduced. This, however, would in no way tend to raise the efficiency of your plant, as it would only be a different way of transferring the heat of the gases to the outside air.

For a given volume of gas, the velocity through a 48-in. stack would be less than the velocity through a 36-in. stack.

2. Kent in the Transactions of the A. S. M. E., Volume 6, gives the following formula:

$$Hp. = 3.33\ (A - 0.6A^{\frac{1}{2}})\ H^{\frac{1}{2}}$$

where Hp. is the horsepower based on coal consumption of 5 lb. per rated horsepower per hour; A is the actual area of chimney in square feet; and H is the height of stack in feet.

3. Another formula, also based on a maximum combustion of 5 lb. coal per rated boiler horsepower per hour is,

$$H = \left[\frac{0.06\ W}{E}\right]^2$$

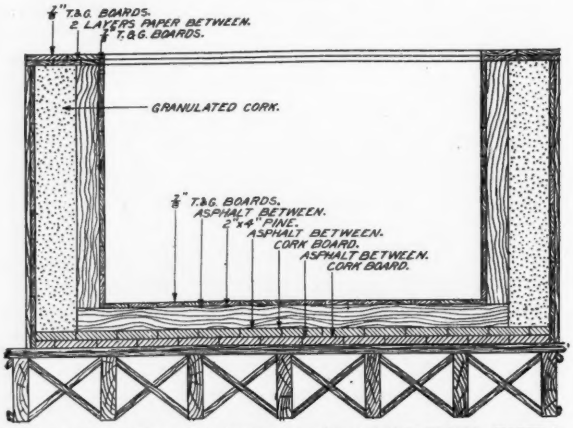
Where H is the height in feet above grates, W is the total number of pounds of coal fired per hour under connected boilers, and E is the effective area of chimney.

From this it will be seen that, with increase of effective area, and therefore, also, diameter of stack, the height would of necessity have to be increased and vice versa.

Construction of Wooden Freezing Tanks

WHAT INFORMATION can you give me on a wooden freezing tank 19½ by 37 ft. and 48 in. high? We have pine available for its construction.

E. K.



SECTION OF WOODEN FREEZING TANK EMPLOYING INSULATION OF GRANULATED CORK AND CORK BOARD

A. Wooden tanks are built of 2 by 4 or 2 by 6-in. planks, according to size of tank, and when built that way, lined with ⅞-in. matched flooring. All the 2 by 4 or the matched flooring is laid and bedded in pure hot asphaltum before being nailed together. Cedar or cypress and hard yellow pine wood are recommended for brine tanks.

In the accompanying sketch is shown a general idea of a foundation, and insulation of granulated cork and cork-board.

Scale for Prevention of Pitting

OUR BOILER INSPECTOR has suggested to us that it would prolong the life of our boilers if we would allow a thin scale to accumulate on their shells. He states that the condensed steam from our drying system is

deleterious, and that the slight pitting in the boilers is a result of its use. There is a great deal of scale matter in our feed water, which is obtained from the Ohio River, and we make a practice of thoroughly cleaning and scaling our boilers once or twice a week. It seems to us that the saving effected in coal would more than make up for any injuries in the boilers. If you will favor us with your opinion on this matter we will very much appreciate it. G. O. B.

A. It is a fact that a water which is too pure—that is, contains no mineral matter in solution—will frequently pit the boiler surfaces somewhat. All water tends to take up mineral matter, and if it has none in it, will absorb a certain amount of minerals or metals, particularly when heated. This is probably the explanation of the pitting in your boiler, if you use the condensed steam from your drying system for a greater part of the boiler feed, as this condensed steam will be practically pure, distilled water. Water from the Ohio River should not cause such pitting, and I judge from your letter does not.

We have heard the theory advanced of allowing a thin scale to accumulate on the boiler shell, but we are not inclined to favor this method of treatment. If you could get a uniform scale, very thin, over those parts of the boiler where pitting is inclined to occur, and maintain that thickness, it might be a solution to the difficulty; but, as you have stated, the presence of scale of any material thickness will reduce the efficiency of the heat transmission materially, and it is impossible, with a water such as you probably have, to control the thickness of this scale.

We would suggest that, under these conditions, you try some one of the forms of boiler metal treatment which have been found, in many similar cases, to work satisfactorily. You will find these advertised by the various companies in Power Plant Engineering.

There is another process which might be satisfactory in your case. This is the feeding of graphite into the boiler.

It will probably be a matter of experiment to find what treatment best meets your needs; but we believe some one of these methods, rather than the accumulation of scale in the boiler, will be the solution to your trouble.

Ice Making Questions and Answers

What number of hours does it require to freeze a 300-lb. cake of ice?

How many cans are usually allowed to a tank, to give 35 tons of ice, every 24 hr.?

Give the approximate cost of manufacturing a ton of artificial ice. (I mean the coal, water, ammonia, wear and tear, etc.) Just give me the number of pounds of coal, and water used, as I can add the remainder of cost to it. W. W.

A. According to information given out by the Triumph Ice Machine Co., a 300-lb. can, having dimensions of 11 by 22 by 44 in., and, where the brine is maintained at a temperature of from 14 to 18 deg. F., will require 60 hr. to freeze.

Under usual conditions, estimates on the size of brine tank, number of cans, etc., are generally made on the basis of the following freezing times: 50 to 72 hr. for ice 11 in. thick; 40 to 60 hr. for 8-in. ice. On this basis, 20 cans are required (300 lb. cans, 72 hr. freezing time, 11 in. ice) for each ton of ice-making capacity per day, so that for a 35-ton plant, 35 times 20 or 700 cans would be required.

As to the cost of manufacturing artificial ice we can of course give you approximate figures only. For every ton of ice, about 2400 lb. of water are required, allowing for loss and leakage, and with good coal (evaporating about 8½ lb. of water per pound of coal). It takes on an average about 1 lb. of coal to produce 7 lb. of distilled water ice by the can system (9 lb. with the better plants).

Data on existing plants show ice production varying from 2.25 to 8.22 tons per ton of coal, the lower value applying to a 5-ton plant and the higher to an 85-ton plant.

With latest can water systems, 10 to 12 lb. of ice per pound of coal are now obtainable. Under exceptionally favorable conditions, raw water plants have shown a production of 15 to 18 lb. of ice per pound of high grade coal.

The total ammonia requirement in ice-making plants is as follows:

Tons ice per 24 hr.	5	10	15	25	50	100
Ammonia, lb.	100	250	500	1000	2000	4000

For a 35-ton plant, you would need about 1500 lb. of ammonia.

The amount of ammonia in a refrigerating plant diminishes in time as a result of leakage and also of decomposition of the substance. Wastage from decomposition can be reduced by keeping down the temperature around the compressor as much as possible. The amount of wastage depends almost entirely on the care exercised, and may reach 200 lb. per year in a plant of 25-ton capacity, although 50 to 100 lb. is generally considered an unavoidable waste for a plant of that size.

Proper Stack Height

How high should a brick stack be to get the best possible draft for three 80-hp. horizontal boilers to burn soft coal? First boiler is about 16 ft. from stack. Altitude is 7500 ft. J. R. S.

A. The size of stack which would be necessary to give you proper draft for your three 80-hp. boilers would be 135 ft. high, with a diameter of 50 in.

We have calculated this from formulas and tables given by Kent, with correction for altitude of 7500 ft., which is common practice with the B. & W. Boiler Co.

You ask for the stack which will give the best possible draft. As you will realize, the draft will increase as the height of stack increases, so that the amount of draft is limited only by the money you wish to put into the building of your stack. The 135-ft. stack, however, would allow for some overload on your boilers, and we believe will satisfy your conditions.

"Waste is worse than loss. The time is coming when every person who lays claim to ability will keep the question of waste before him constantly." (Thomas Edison.) Edison buys War Savings Stamps.

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Comments on the Fuel Situation

To those who have been watching the coal market conditions, it is gratifying to note that the production is on the incline. Returns from the operators for the week ended June 28, the latest report received from the U. S. Geological Survey, report a general improvement in market conditions, the loss of time on account of no market averaging 29.2 per cent against more than 32 per cent in the first half of June. While this is encouraging to a certain extent, we still fall 200,000 T. a day short of the production in 1917 and over 400,000 T. below the 1918 production.

Not alone in this country is the coal production short, but it is even more alarming in Europe, where it was usually thought that with the coming of peace, despite the appalling destruction of French collieries, the difficulty of Europe supplying itself with coal would pass away. There are greater factors entering into the situation than the 3 per cent reduction due to war devastation in France; these are principally labor unrest, changes in labor conditions and military fighting in Silesia, Poland and Bohemia. This coal condition, according to George S. Rice, of the Bureau of Mines, is likely to be still more serious unless the United States can come to the rescue by an extensive program of exporting. He bases this opinion largely upon the fact that England in 1913 exported 77,000,000 long tons, while, due to shortened hours of labor and other conditions, this country will have but 7,000,000 tons for export during the coming year. France, Italy, Sweden, Norway and Spain have depended largely upon Great Britain for fuel, but will have to look somewhere else now. This being the condition, it is more than likely that the United States, with a growing merchant marine, will endeavor to supply some of the deficiency in foreign countries.

While studying the fuel situation, let those in the power plants of the country not overlook the possibilities of fuel oil for use under their boilers. The lack of a coal market may, in fact, be partially due to an increasing use of fuel oil in industrial plants. According to C. E. Backus, chairman of the fuel oil committee of the National Coal Association, the coal market is threatened with demoralization, due to the increased use of Mexican petroleum as fuel, and coal producers are preparing to fight for a protective tariff on imports of oil.

Many factors combine to place fuel oil in a favorable position especially along the seaboard where transportation by tanks, released from war service, is comparatively cheap. The demand for fuel oil was cut short when the navies ceased extensive operations, and the expected increase in production of Russian, Roumanian and other European oil fields has its bearing on forcing oil interests to seek a more extensive market in competing fields.

Then again, the demand for the refined oils such as gasoline, kerosene and lubricating oils is out of proportion to the fuel oil which remains as residue after the refining process. The oil interests are, therefore, out for a market for this product and it is only natural that they should cut into the coal field.

Those plants equipped to burn fuel oil under their boilers apparently have a rosy outlook, but the situation is still too unsettled to warrant wholesale abandonment of coal as fuel and those who do change over should study

their individual conditions carefully beforehand. The oil market is, as a rule, not so steady as that of coal and to depend upon oil alone may not result in economy even though present prices would show a saving over coal.

Experience—Its Value

What has been his experience? How often this question is raised in judging a man's fitness for greater opportunities.

Memory is a powerful factor in experience. The man of experience is such by virtue of the store of impressions which he has gathered and filed in his mental storehouse to be available when their influence is required to decide a course of action along a topic to which they are related.

When a plan is presented to an experienced engineer for his opinion as to practicability, mental photographs of similar works with which he has been connected in the past, present themselves for service. They assist in forming his opinion as to whether the proposed plan is sound and worthy of further consideration or immediate action. This is experience—a valuable asset.

Although the claim is made that engineering is an exact science, no method has been evolved to apply this science to the ever changing conditions. And again experience steps in to fill the void.

Alone, experience will not carry a man through to his ultimate goal in power plant work—it requires ingenuity, loyalty, study, sympathy, and a vision of greater service to round out his real value. These characteristics should not be overlooked in measuring a man's ability. All too frequently, because of their inherent invisibility and peculiarly personal nature, these factors are not listed on the credit side of the ledger, and Old Man Experience cultivates an exaggerated idea of his importance.

Safety Engineering

The experiences, conclusions and advices of 4000 of the country's largest industrial establishments which employ an aggregate of 7,000,000 workers and spend a total of $20,000,000 a year in accident prevention work, has recently been made available to industry generally by the National Safety Council through a series of lectures on different phases of industrial safety work, some of which are to be presented to our readers.

These lectures comprised the curriculum of schools for safety engineers—the first of their kind in the world—conducted by the National Safety Council at St. Louis, Cleveland, Pittsburgh and Rochester, N. Y. At the St. Louis school, the first to complete the course, 240 of the 504 students received the degree of Supervisor of Safety. Among the men who took the course were plant owners, general managers, superintendents, foremen, house physicians, employment directors and practicing safety engineers.

Plans are now under way for the establishment of safety schools in many other cities in which the course on safety engineering will be supplemented by one on industrial relations, as the two go hand in hand.

The magnitude and possibilities of industrial safety engineering will be appreciated when it is known that in the 4000 plants now maintaining distinct safety departments deaths from accidents during the last five years were reduced from 35,000 to 15,000 yearly. In other words, industrial accident prevention work in the United States is now saving the lives of 20,000 workers yearly.

During the same five-year period serious, though non-fatal, accidents were reduced from 750,000 to 500,000 yearly in the plants practicing safety work.

Equally significant is the statement of C. W. Price, general manager of the National Safety Council, made at the commencement exercises of the St. Louis School for Safety Engineers, that one-third of the accomplishments of accident prevention work were brought about by the installation of mechanical safety guards and two-thirds of these accomplishments were due to the employment of educational methods.

The safety practices outlined in the lectures to be presented in Power Plant Engineering are applicable to any industry. In the words of Mr. Price: "This course places in the hands of the reader the experience of all the industries of the United States during the last twelve years. The reader starts in where the United States Steel Corporation left off in the safety work through which in the last twelve years it saved 23,000 men from being killed or maimed in its own plants."

The first lecture of the series is published on another page of this issue.

Keeping a Turn Ahead

In the course of his flying instruction, the cadet is frequently urged to look above and below and in all directions, to watch continually for other airplanes, and to have the next move always in mind. He is told "to keep a turn ahead of his ship."

Do we, in our power plant thinking, apply this doctrine of preparedness to our peculiar engineering activities in the full measure that we should, or do we bask in the comforting, restful atmosphere of "let well enough alone"?

To anticipate intelligently our future power demands and provide ample space for additional units, to estimate the probable life of present equipment and plan for its replacement with the most efficient sizes and types, is quite likely to be considered premature—crossing the bridge before we come to it.

Visualizing future problems of your station and giving real thought to their solutions, forging ahead of the actual demands of the moment, studying relevant subjects which some day may prove invaluable, will widen your ability and strengthen your guarantee of success. Merely keeping an eye on the boss's chair is not "visualizing."

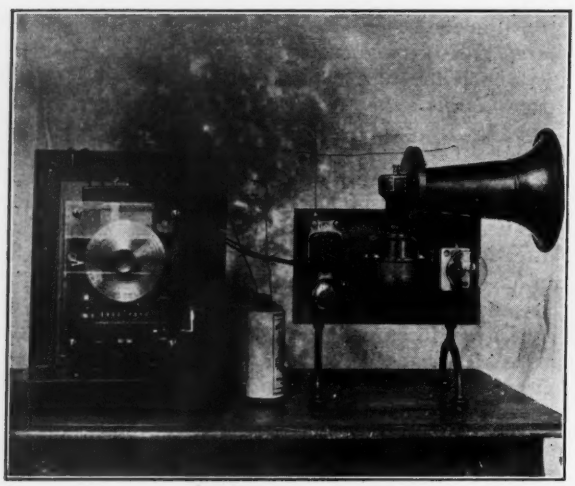
Be sure to keep a turn ahead.

AN ELECTRIC APPARATUS for detecting small power losses and so determining the efficiency of gears has recently been perfected by C. M. Allen, Professor of Hydraulic Engineering at the Worcester Polytechnic Institute. A number of tests were made with this apparatus to determine the best sort of gear lubricant. The best results were obtained with a mixture of heavy oil and flake graphite. With a perfect blending of the oil and graphite there was a minimum loss through friction.

Audible Electric Signals in Industrial Plants*

By V. Karapetoff

NO industrial plant of any magnitude may be considered fully efficient unless means are provided for promptly locating any important employe, no matter where he may be within the plant. A private telephone system, however extensive, serves this purpose only as long as the needed man is at his desk, but as soon as he leaves his desk the problem of locating him becomes a hit-or-miss proposition. On the other hand, a superintendent, a foreman, a millwright, a repair man, etc., is ordinarily useful only in so far as he can freely move about the shop without the fear that someone of importance may need him. Thus, within the last few years, under the tremendous impetus of the pressure for an enormous increase in the production of munitions of war, audible electric signals have been introduced into many industrial plants.



CODE-CALLING INSTRUMENT AND THE SIGNALS IT ACTUATES; VIZ., AN ELECTRIC HORN, A BELL AND AN ELECTRIC LAMP

Such an electric signal is usually similar in construction to the familiar electric "horn" used on automobiles. It consists of a diaphragm with an anvil at its center. A toothed wheel driven by a small electric motor strikes the anvil many times a second and causes it to vibrate vigorously. These vibrations produce the well-known warning tone, which carries over a considerable distance. The device is provided with a projector or horn the shape of which depends on whether it is desired to scatter the sound, to intensify it in horizontal direction, or to deflect it downward. Such motor-driven signals are now made much more powerful than automobile horns, and are wound for 110 or 220 v., direct or alternating current, so that they can be connected to a lighting or power circuit, and do not require a separate low-voltage battery.

With such electric audible signals scattered throughout the plant, it becomes an easy matter to locate instantly any person to whom a code number has been assigned. For example, when the manager wishes to speak to one of the assistant superintendents, who may be anywhere in the plant, he simply tells the telephone operator to sound this particular man's call. As soon as this assistant superintendent hears his call he comes to the nearest telephone and reports, whereupon the operator connects him with the manager.

It would be rather inconvenient for the telephone operator to sound various calls by hand; therefore a special code-calling automatic instrument has been developed for this purpose. The operator merely sets the desired person's code number on a dial and pulls a lever; a contact-making mechanism is thereby set in motion, which closes the electric circuit and operates the code signals throughout the plant the required number of times (usually three times) and then stops automatically.

In noisy and in open places the electric horns constitute the most suitable type of signal. In offices they may be replaced by less loud electric gongs, bells, buzzers, air whistles or incandescent lamps. In some cases two separate circuits are run from the code-calling mechanism, one circuit for ordinary calls, the other for fire-alarm gongs, or for some other special purpose. Sometimes two allied plants are operated side by side with a separate staff in each. Then the same code combinations can be assigned in both plants, but the horns in one or the other plant will sound according to which of the two circuits is closed.

A further application of loud electric horns in industrial plants is for extensions to telephone bells. The ordinary telephone ringer is not loud enough in many shops when the foreman is away from his desk. In this case a relay is connected in parallel with or in place of the telephone ringer, and when it is actuated it closes a secondary circuit, which causes an electric horn to sound. This call should be a single blast to distinguish it from code calls.

Audible electric signal systems are also used in various plants as warning signals on cranes and hoists, also to call a shifting locomotive, to indicate the beginning or the end of a certain operation, and for other local purposes.

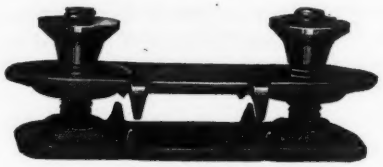
*Abstract of paper presented before the Rochester, N. Y., section of the A. I. E. E.

The High Duty Fastener

RECENTLY perfected and now being manufactured is a remarkable belt fastener, designed for heavy belting and made in sizes for belts varying from 3/8 in. upwards in thickness. The simplicity and strength of design of this new device, which has been named the "High Duty" fastener, have met with the unqualified approval of mechanical men to whom it has been submitted.

The High Duty fastener embodies a new application of the compression principle as applied to belt fasteners. It consists of two rectangular steel plates, which clamp on either side of the belt and are connected by bolts which go through the belt. The top plate has two round holes which are countersunk to hold the special cone shaped nuts, while the bottom plate has two special square seats which fit around the square heads of the bolts.

The tendency toward increasing thickness in conveyor belts has demanded a new type of joint, as no satisfactory heavy fastener was available. This new fastener is simple to apply; it takes only a reasonable time in proportion to the size of the belt. The sizes of these fasteners are proportioned to the thickness of the belt for which they are designed.

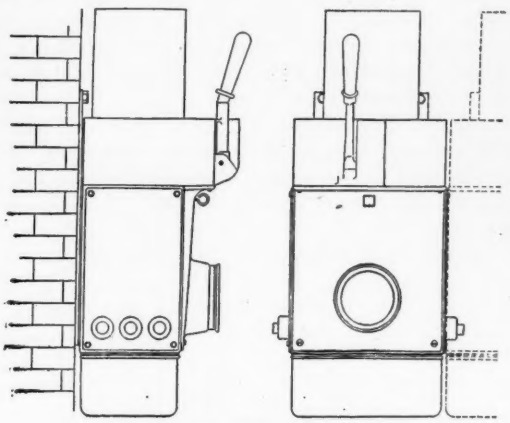


NEW TYPE OF BELT FASTENER

The illustration shown herewith is from a photograph of the fastener and shows the construction of the upper and lower plates as well as the special bolt and nut.

Wall Type Switching Unit

THE wall type switching unit here shown and intended for the control of alternating current circuits up to 300 amp. and 2500 v., consists of an industrial type oil circuit breaker with a space above which serves as a housing for disconnecting switch, current and potential transformers, and also provides a location for either voltmeter or ammeter, or both, when desirable.



WALL TYPE SWITCHING UNIT

Following along the lines of safety-first principles, the disconnecting switch is interlocked, mechanically, with the oil circuit breaker, so that the switch cannot be opened when the breaker is closed, nor can the breaker be closed while the disconnecting switch is open. A key projecting through the front of the panel is used to operate the disconnecting switch. This key can be removed when the switch is open, and carried by the operator, who then is assured that no one will close the switch while he is working on lines or apparatus on the circuit controlled by this unit. The interior of the switch compartment is inaccessible while the switch is closed, and the oil tank cannot be removed while the disconnecting switch or oil circuit breaker is alive.

These switching units are particularly adapted to the control of circuits feeding banks of transformers; motors in steel mills and pumping plants, where it is desirable to mount the motor control appliances on walls or pillars.

The units are designed for single or group mounting and have a large bus compartment just above the disconnecting switch and inside the cast-iron housing. Conduit connection with the unit can be made from above, below or from either side.

Immense Shipment of Rubber Belting

A SINGLE order of belting containing 44,254 ft.—approximately 8½ mi.—was shipped recently by the B. F. Goodrich Rubber Co., Akron, Ohio, for the Pennsylvania Railroad Company's new grain elevator at Canton, near Baltimore, Md. The shipment, valued at more than $125,000, is probably the largest single order of rubber belting ever shipped. Seven box cars were required to transport the 131 tons of conveyor and elevator belt which comprises complete grain handling equipment of this mammoth terminal grain elevator.

WORLD'S LARGEST RUBBER BELTING SHIPMENT

This belting will handle, store and trans-ship western grain reaching the coast over the Pennsylvania Lines, the elevator being specially designed for loading vessels for export and coast-wise trade. It is interesting to note that this belting equipment will make possible the handling of approximately 2,000,000 bu. of grain daily.

The announcement of the completion of this monster grain elevator brings sharp realization of America's dominant position in world grain production and shipping. The elevator was designed and constructed by the James Stewart Co, Chicago, who are among the world's foremost grain elevator engineers, and the structure represents the last word in this type of engineering.

The rubber belting as packed for shipment shown in the photograph is of two types, elevator and conveyor. The elevator belts are 32 and 38 in. in width, while the conveyors are 36, 42 and 48 in. wide. The capacity of one of the 48-in. horizontal carrier belts is 350,000 bu. in a 10-hr. day.

News Notes

LEA-COURTENAY CO. announces the appointment of H. T. Sward as district manager with offices at 1466 Conway Building, Chicago.

R. T. COE, Insurance Building, Rochester, N. Y., has been appointed representative of the Steam Motors Co. for the Rochester district.

PLANT ENGINEERING & EQUIPMENT CO. has opened branch offices in Kansas City, Mo., 312 Elmhurst Bldg.; Salt Lake City, Utah, 17 Exchange Pl., and Charlotte, N. C., 815 Independence Bldg.

S K F INDUSTRIES, INC., 165 Broadway, New York City, announces the establishment of a Chicago District Office, in charge of John B. Castino, at 1314 Marquette Bldg., Chicago.

THE SUPERNO CO., together with its active organization and other interests, have been taken over by the Peerless Superheater Co., a newly formed corporation, with offices at 52 Broadway, New York City.

THE BUSINESS of The Gauld Co., Portland, Ore., has been taken over by The Gauld Supply Co., Inc., under the laws of Maine. The directors of the new company are: Wm. P. F. Ayer, president; Thos. Nickerson, vice-president; G. A. Ricker, treasurer; Theo. W. Little and Carl T. Keller, all of whom are prominently connected with the Walworth Manufacturing Co.

THE CHICAGO PNEUMATIC TOOL CO. announces the appointment of L. C. Sprague, formerly District Manager of Sales at New York, as Manager of Western Railroad Sales, with headquarters at Fisher Building, Chicago, and H. G. Barbee as Manager of Eastern Railroad Sales, with headquarters at 52 Vanderbilt Ave., New York City. Nelson B. Gatch, formerly District Manager of Sales at Chicago, has been appointed District Manager of Sales at New York, succeeding Mr. Sprague.

C. F. MILLER, who has had charge of the Los Angeles office of the Dearborn Chemical Co. for many years, has resigned and assumed the management of the Independent Speedometer Repair Co. of Los Angeles. Alex B. Burns has been appointed manager of the Stationary Department of the Dearborn Chemical Co. on the Pacific Coast, with headquarters in Los Angeles. Mr. Burns has been with the Dearborn Co. on the Coast for several years in the position of Supervising Engineer.

THE UNITED STATES SHIPPING BOARD announces that it has vacancies for 1500 firemen in the Merchant Marine. The age limit is from 18 to 35 yr.; minimum weight, 140 lb. The pay of the marine fireman is $75 a month, with board and quarters free.

THE UNITED STATES CIVIL SERVICE COMMISSION announces the following open competitive examinations for men and women draftsmen to fill vacancies in the Navy Department, but competitors will not be required to report for examination and no definite date is set: Ordnance, Marine Engine and Boiler, Marine Engine and Boiler (Internal Combustion), Marine Engine and Boiler (Aero), Marine Electrical Radio, General Engineering, Architectural, Power-Plant, Heating and Ventilating, Ship, Copyist, and Aeronautical. The salaries range from $5.20 to $12 per day. Further information can be secured from the U. S. Civil Service Commission at Washington, D. C., or any of its branch offices.

U. S. CIVIL SERVICE COMMISSION announces an examination, Aug. 19, for inspector (mechanical), for men only. A vacancy in the Public Works Department, Navy Yard, Mare Island, Cal., at $7.04 a day, and future vacancies requiring similar qualifications, at salaries ranging from $4 to $7.04 a day, will be filled from this examination. Competitors will be rated on physical ability, education, training and experience, and must have reached their twenty-first birthday on the date of the examination. Apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

Books and Catalogs

INDUCTION COILS IN THEORY AND PRACTICE, by F. E. Austin; 61 pages, 45 illustrations; first edition, 1919; Hanover, N. H.; price, $1.

Due to its extensive use in the fields of automobile engineering, wireless communication and electro-therapeutics, the induction coil is one of the most important electrical devices of the present time. Spite of this, however, but little comprehensive information relative to the underlying theory of operation of this piece of apparatus is available, therefore, without doubt, this little volume of Prof. Austin will find and should find a ready welcome in the hands of those having to do with induction coils. It ought to be of particular value to automobile and aircraft owners, operators and repair men, those engaged in wireless telegraphy and telephony and those employed in the design, construction and care of electrical apparatus used in medical work.

Not only is the theory of the induction coil handled in a very able manner, but with the assistance of the explanations of the fundamental principles given the mechanic should with little trouble be able to construct induction coils to meet a variety of demands as well as to construct coils to fulfill specific requirements.

Numerous practical examples with the many illustrations presented will enable the student to grasp the full meaning of the discussion. Little mathematics is involved, thus adapting the book to the needs of the man with but limited technical training.

DRY CELL INFORMATION is covered in full in a recent publication of the Bureau of Standards entitled, "Electrical Characteristics and Testing of Dry Cells." This publication, known as circular No. 79, gives a brief description of materials of construction and elementary theory of the operation of cells. The various kinds and sizes of dry cells are mentioned and the electrical characteristics of the cells and methods of testing are discussed. Indeed, this little book of 44 pages, which may be obtained for 10c by addressing the Superintendent of Documents, Government Printing Office, Washington, D. C., removes much of the mystery which is generally supposed to exist in the manufacture of dry cells.

A BOOKLET on "Facts for Operators of Electric Hoists," prepared by the Engineering Committee of The Electric Hoist Manufacturers' Association, is available to all interested by applying to the secretary, W. C. Briggs, 30 Church St., New York City. A new booklet on track, supports, current conductors, etc., will be issued soon.